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PERSONALITY STUDIES OF THREE-YEAR-OLDS

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INTRODUCTION

There is no need to expatiate upon the lack of scientific information about the mental life of small children. The fact is only too well known. With our growing belief that the experiences of early childhood have a powerful and permanent effect on character and personality, the lack of knowledge about the mental capacities and types of reaction of very young children seems an even more serious omission. Furthermore, we are becoming more and more disturbed by the fact that the care and training of children up to five years is still exclusively in the hands of mothers who come, without specific training, to a task so important that it may determine the success or failure of their children before the organized agencies of the community for the training of children touch them at all. So keen is the realization becoming of the danger of making no provision for the study or training of very young children, either directly or through the training of mothers, that it seems probable that the next large new development of the educational system may take the form of some type of provision for this lack.

If training for all young children, or for all mothers, potential or actual, is to be provided by the community, it is obvious that the public-school system is the only agency adequate to the task. It is possible for private agencies, however, to carry out experiments which may demonstrate

[1] The physical examinations referred to in this paper were made by Dr. C. A. Wilson of Detroit. The laboratory tests of blood and urine were made by Dr. Paul G. Woolley at the National Pathological Laboratories. The mental examinations were given by Miss Elizabeth Cleveland, working at the school laboratory under the direction of the writer. The records of behavior were made by the college students, and various members of the staff who came in contact with the children.

both the value and the practicability of new educational ventures. The Merrill-Palmer School of Detroit is undertaking an experiment in which the two purposes of providing suitable training for young children, and of developing courses of training in the care and management of young children for prospective mothers are made to supplement one another. A nursery school for children between a year and a half and five years of age has been established, and a course of training in the care and management of young children for college students. The college girls who are in residence get their practice work in health and nutrition, and in the psychology and training of young children by acting as assistants in the nursery school. The children in the school are in immediate charge of Miss Emma Henton, from the Gipsy Hill Training College in London. Miss Henton was in charge of the nursery school established at the college under the provisions of the Fisher Act.

Under the plan of organization, each of the thirty children in the school becomes the subject of as careful a study of personality as we find it possible to make. Every child has a complete physical examination, and as thorough a mental examination as we can make with the imperfect tools now at command. In each case a personal history of the child, and a brief family history is recorded. Continuous records of height, weight, feeding, and types of reaction under varied conditions are kept. Needless to say each child stands out as a personality as distinct to those who take the pains to know him well, as adult acquaintances, though we hope not so immutable.

The following studies of two of the three-year-old children in the school are offered first for publication because they seem to us interesting examples of the kind of experience in young childhood which is frequently held responsible for warped, or even pathological types of personality later on.

Mary Jane

Case of Phobia in a Three-year-old Child

Age: Mary Jane entered the school in January, 1922, when she was three years and eight months old.

Physical Condition: Mary Jane's physical condition was perfect. The doctor rated her in the highest class for general condition. Her standards of height and weight were both above those of her age. The Wassermann test was negative and blood count and urine analysis showed no deviations from normal.

Mental Development: On the Stanford Revision of the Binet scale Mary Jane had an intelligence quotient of 133. Her rating on a series of performance tests was in the one hundredth percentile for her age in two of them, in the ninetieth percentile in a third, and in the sixtieth percentile in a fourth. These performance tests were standardized in the laboratory of the Merrill-Palmer School, and will be published soon.

Appearance: Mary Jane is a large, very healthy looking child with fair curls, blue eyes, a round rosy face, and a winning smile that frequently displays her white teeth.

Character and Disposition: Her most outstanding characteristic was her constant happiness, good temper and coöperative spirit. There was never a conflict of any sort with Mary Jane at the school. She was always ready to help with the work and join in the plays. In the little tasks of the school she was competent and reliable. She always knew exactly what she wanted to do when the choice of work was left to her and she stuck to one task until it was finished. Her father reported that she was frequently stubborn at home, but, although she was so very positive in her plans and ideas, we did not find her stubborn at school. She sometimes failed to obey immediately but was never really resistant to reasonable demands. Mary Jane showed signs of being in a certain sense rather nervous. In telling a story she frequently trembled with excitement and her hands shook. It was noticeable that her hands shook when threading beads, but she was never irritable. Her control of her body was excellent. She had a good sense of rhythm and could march or skip to music more accurately than most of the children.

Home Background: The child is of Norwegian descent on both sides, though she herself and her mother were born in

this country and her father came here as a child. Her father is a doctor and her mother was a trained nurse before her marriage. Her grandparents were merchants and farmers. At the time of her entrance, Mary Jane was a first and an only child. Her parents are exceedingly interested in Mary Jane, and devoted to her, and on the whole wise in their management.

History of the Development of the Phobia: On March 7, when Mary Jane was three years and ten months old and had been about six weeks in the school, she stood at the top of a flight of stairs one day after the other children had gone down and began to cry. When one of the college students went up to find out what was the matter she insisted that she was afraid to come down the stairs and must have someone take her hand and walk next to the railing. Her eyes looked panic stricken and she trembled. When asked what she was afraid of she pointed to the two spindles of the railing nearest the top post. The only reason she could give for being afraid was that there wasn't any curtain. The child had been up and down these same stairs several times a day every day since entering the school and we were totally at a loss to account for this sudden intense fear. Much to our surprise the fear lasted for about four weeks. Day after day Mary Jane stood at the top after the other children had gone down, full of fear and distress and totally unable to force herself to descend the familiar straircase. She kept repeating amid her tears—"I can come up all right. I am not afraid to come up, but I can't go down. I am afraid to go down." The genuineness of her distress and her inability to understand what had caused it seemed unmistakable to us. We did everything we could think of to overcome it. We talked to the child about the railing and told her it was there to help her and keep her from falling. We finally got her to touch it herself, though it was evidently a fearful ordeal, and gradually by coming down with her and urging and encouraging her we got her to the point where she could come down with comparatively little trepidation. Her mother was totally at a loss to account for the situation. During this

period she displayed the same type of fear of a similar bannister which she encountered in a department store when her mother was with her. At the end of about four weeks, when we felt that her fear was in a large measure conquered, a vacation of over a week occurred. Since that time the child has apparently completely overcome the trouble.

We were totally at a loss to explain the situation. Our only theory at first was that something had happened to frighten or disturb her when she happened to be looking at that part of the banister, but since she could not explain it and no one was with her at the moment, we were somewhat hopeless about finding out what had really happened. It then occurred to us that possibly the history of the development of phobias in adults might lend some clue this case. In adults the condition seems to be connected with suppressed ideas related to sex. We then recalled the fact that about two weeks after Mary Jane entered the school, on February 7, a baby brother had been born. Mary Jane had talked about the baby at school most affectionately and had displayed a great interest in him. Her mother reported that she seemed delighted with him and had displayed no trace of jealousy. One day when I was in the nursery she came up to me and began talking about the birth of the baby. She said, "When mother went to the hospital she didn't have the baby and when she came back she had it." She repeated this several times with a rather strained look on her face and I felt sure that the whole problem of the baby's birth had worried her. It suddenly occurred to us that her fear of the stairs might be in some way connected with the event of the baby's birth and her experiences in connection with it. Accordingly I sent for her mother to inquire the details. Her mother told me that the baby was born in a hospital and that Mary Jane, on her way to school, was brought to the hospital by her father to see the baby each morning. I inquired whether she went up or down stairs at the hospital and her mother replied that she never walked up stairs because they always came up in an elevator, but that they frequently walked down stairs after

the visit because the elevator was not at hand. I inquired if she knew what kind of a staircase it was and she said that she did. The stairs were visible when her door was opened and she could frequently see Mary Jane and her father start down them. She described a staircase with a short flight of five or six steps at the top and a banister with upright posts at the side. This was exactly the situation with our stairs at the school. I was at once struck with the remembrance that Mary Jane had kept saying, "I can come up all right but I am afraid to go down." I also asked the mother whether they had talked with Mary Jane at home about the arrival of the baby. She said they had not mentioned it to her because they thought she was too young to understand about it. She and her husband had several times mentioned the fact that Mary Jane had never asked any questions about the baby's arrival. This set of circumstances seem to me conclusive in proving that the disturbance was due to her concern about the birth of the baby, the fact that in some way she had been made to feel that it was a topic on which she couldn't ask questions at home, and her continued anxiety about it. On coming out of her mother's room, with her mind full of anxiety and distress about the problem of the arrival of the baby which she did not dare voice, the first object which met her gaze was the staircase with its short flight of steps at the top and the upright posts of the banister. Her problem found no solution, but kept on distressing her in secret until it forced some sort of expression. Finding herself again in a situation so similar to that identified with her suppressed anxiety, suddenly and unaccountably to herself, gave rise to her experience of fear. I explained the matter to her mother who promised to talk to Mary Jane at once about the birth of her little brother, and to try to forestall possible future effects from this very vivid experience.

This is the second case of phobia in a young child which I have personally encountered. The other one I did not succeed in analyzing. A physician in Detroit who is a specialist in children's diseases told me that he had met with five or six cases of phobia in his practice among children

about three or four years of age. He seemed to have no theory to explain the phenomenon. We were particularly interested in being able to unravel at the time the type of experience in young childhood which is frequently held accountable for the development of mental abnormalities in later years. Very few individuals remember definitely events that occur between three and four and are therefore frequently quite unable to find the clue to their own difficulties without outside aid.

Bobbie

A Case of Mother Complex

Age: On entering school in January, 1922, Bobbie was three years and six months old.

Physical Condition: Bobbie's physical condition was only good. He was above the standard of height and weight for his age, but was rated only 2 by the doctor. He had a previous rachitic history and had had one convulsion before his entrance to the school. During a school vacation, after he had entered, he had another convulsion which terrified his parents. They sent him to the Ford Hospital for a complete physical examination. The doctor reported that he found signs of a previous encephalitis. His Wassermann test was negative and the blood count and urine examination showed no abnormalities.

Mental Condition: On the Stanford Revision of the Binet Scale Bobbie had an intelligence quotient of 105. He failed in two of the four performance tests but since so many of the three-year-olds failed in these tests, this had no consequence other than to show that he was not very superior. In two of the performance tests he succeeded with ratings in the 60 and in the 80 percentile.

Appearance: Bobbie is a rather solemn little boy, large for his age, with a rather large head, stiff stubby light hair, and somewhat bulging forehead. He is awkward and rather unattractive.

Character and Disposition: Bobbie proved to be a difficult child—resistant to suggestion, uncoöperative and unable to play normally with the other children. He was greedy and

selfish. At table he stuffed food into his mouth with his hands, not caring what became of the rest just so his mouth was full. He fairly swallowed it whole. It was exceedingly difficult to interest Bobbie in the normal activities of children of his age. Neither was he interested in the other children. His attitude toward them was on the whole one of indifference, with occasional displays of hostility. He never seemed to have any projects of his own. His movements were awkward and rather poorly controlled. He had less sense of rhythm than most of the three-year-olds.

Home Background: Bobbie's parents had neither of them had any education beyond that of the elementary schools. His father is an unusually intelligent man who is superintendent of a large plant in the city. The mother was a factory operative before her marriage. His grandparents were all native born. They were farmers, artisans, and domestic servants. There was one other child in the family —a young baby.

Development of the 'Mother Complex': Bobbie was first brought to school by his father who reported the following conditions. The mother had lost one child previous to the birth of this one. She was a highly emotional and somewhat violent-tempered woman with no interests outside of her own home. When this child came she lavished all her affection on him. He was never away from her and she gave him a very unwise amount of petting and physical display of affection. When his father tried to interfere and secure some wiser discipline it led to family dissension with the result that apparently the boy was gradually set off against his father. The mother had very little real control over him, and when he began to get older and more troublesome she would say to him, "If you don't behave I will tell your father when he comes home and he will punish you." This, combined with the fact that whenever the father attempted any punishment the mother interfered in Bobbie's behalf, gradually produced a condition in the child which was most pronounced when he came to the school. What we noticed was that he was interested in nothing except securing atten-

tion and petting from some adult female. Neither the toys, occupational materials, nor the children interested him in the slightest. He would stand around watching the students until he saw one who seemed inclined to pet him and give him some attention; then he would hang on her skirts as long as he was allowed. Each new student or visitor who came to the school was the object of attacks from Bobbie. He whined and fretted and begged for attention all day. In the afternoon when it drew near the time for his father to come for him, Bobbie would frequently begin to say, with a look of complete conviction, "My daddy won't come for me; he won't come." This he would repeat over and over again until stopped. Occasionally he would vary this by beginning to chant, "My daddy's dead; my daddy's dead; my daddy's dead," over and over again. When his father finally appeared Bobbie would rush for him, grab his legs and begin to demand to be petted. This obviously annoyed his father and he would push him off.

Bobbie frequently remarked that he wished he could wear dresses and be a little girl and that he would like to be a woman when he grew up. When somewhat later the little girls in the school made up a game of playing bride and decked themselves with old lace curtains for bridal veils, Bobbie was very insistent that he wished to be a bride too, and utterly disgusted when the students were unable to make the bridal veil stick on his stubby hair. No other little boy in the school displayed any desire to play the part of bride.

We discovered by chance that he seemed to have a general distrust of men. One day he was taken to the house of one of the members of the staff to be brought to school by her. When he saw her brother in the house he appeared to be frightened and objected to going in because "There is a man in there" and demanded to know, in a somewhat hostile manner, who it was. He was told it was her brother, Fred, and that he liked little boys, but Bobbie would have nothing to do with him and clung to Miss Rodgers until Fred had left the house. Later he wished to know to whom the car in the garage belonged and when he was told it was Fred's he

again seemed alarmed and wanted to know if he had to be taken to school in Fred's car. He was obviously relieved when assured that he was to be taken on the bus.

He was allowed to sit at Miss Rodgers' desk while she was getting ready for school and was told that he might have some paper and a pencil (which were given him) but that he must not touch anything else. In spite of this injunction he played with a bottle of ink and spilled some. When Miss Rodgers discovered it and rebuked him for it his first words were, "Don't tell Fred, you won't tell Fred, will you?" When his attention was called to spots of ink on his clothing, he said, "That will come out with water."

In spite of his disgusting methods of eating, Bobbie was inclined to be very careful about his clothes, and was worried when he got them dirty. Since his mother did all of her own work, including the washing, she had doubtless put stress upon the virtue of keeping his clothes clean. Several times in the course of a day Bobbie was apt to ask if his clothes were dirty yet, or call attention to the fact that they were still clean. His efforts were really effective, and the end of a day usually found him noticeably cleaner in clothing than the other little boys. His preoccupation with cleanliness of clothing was one thing that prevented him from joining in many of the children's pursuits.

During the course of his stay of five months in the school, in spite of the fact of frequent periods of absence and rather irregular attendance, Bobbie improved very much. He got to the point where he could occupy himself independently with the toys or beads or clay modelling. His incessant demands for attention were abated and his food habits and habits of eating enormously improved. He seemed a fairly normal child at the end of the term, though his great preference for women and his dislike and distrust of men were still evident. Though his father had never failed a single time to come for him, Bobbie was still apt to begin his monotonous chant of "My daddy won't come, my daddy won't come," and occasionally, "My daddy's dead."

The fact that about the time of his entrance to the school

another baby was born into the family probably has much to do with Bobbie's improvement. His mother's time and attention and excessive emotional energy were turned off in part in another direction and Bobbie was somewhat freed from the incubus. It seems to us, however, that his character and disposition have been given a slant which it will be exceedingly difficult to overcome completely.

THE COLOR PREFERENCES OF FIVE HUNDRED AND FIFTY-NINE FULL-BLOOD INDIANS

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Introduction and Problem

One of the ways of looking for racial differences is to seek them in the field of æsthetics. We have objective facts of a more or less complex character in the art and music of isolated races that suggest just such differences.

In fact popular and a large body of scientific opinion seem to hold to the view that there are fundamental racial differences in æsthetics. Now if there are, *i.e.*, if they are really racial, they are *a priori* native. Being native they are to be regarded as the results of the inheritance factors carried by racial germ plasm.

We mean to say that just a difference, as found, does not mean a difference due to physiological heritage. The differences due to mere environment and circumstance, if these really be found, are not the differences sought.

It is the problem of this experiment, if possible, to find just racial differences, those due to physiological transmission. However in the attempted solution of the main problem other subsidiary problems arise, such for instance, as the influence of education.

Deeming it wise to avoid undertaking the solution of one of the more complex problems of racial æsthetics, we sought a very simple phase of the larger problem by confining our investigation to a study of racial differences in color preference.

It would seem best in an experiment which has for its task the determination of racial differences in color preference to break the problem into three parts:

1. To determine an order of preference for the colors used which might be said to obtain and to find preference values for the colors in the race studied.

2. To ascertain if the preferences, or orders, so determined could be said to be native or acquired for the group.
3. To find out if these preferences are peculiar to the particular race as compared with other races tested under similar circumstances and with the data treated in the same way as the race under consideration.

The Subjects of the Experiment

In the spring of 1921 the writer visited the United States Indian schools located at Chiloco, Oklahoma, and at Albuquerque, New Mexico, for the purpose of giving psychological tests to Indians. This expedition was financed through the courtesy of the Committee on Grants of the American Association for the Advancement of Science. Because it would seem that the element of education, a very important factor in the experiment, could be more nearly controlled, students in these schools were sought as subjects. In this comparisons with white subjects would be more nearly legitimate.

The group whose tendencies we wish to study here is one of full-blood Indians having the ancestry of Plains and Southeastern Indians and of Plateau Indians. Of the first of these there were 281 individuals and of the second 278.

For purposes of comparison as many Indians of mixed blood as were available, 174, and a group of 560 whites were tested with the same color material. The mixed bloods considered, were in fact, a mixture of white blood and Indian blood of the tribes represented in the full-blood group. Unfortunately the number of these mixed bloods is too small for the drawing of definite conclusions from any comparison with the full-blood Indians, and the white performance. As they performed the experiment, the mixed and full-blood Indians sat side-by-side in the school room and the experiments with the whites were administered under conditions as nearly the same as those for the Indians as was possible.

The Materials of the Experiment

As to the materials of the experiment they were seven color discs, of Milton Bradley Company's 'standard'

colored papers: Red, Orange, Yellow, Green, Blue, Violet, and White. All the colors are printed on what is called 'coated papers.' By 'standard' it is meant by the makers of the papers 'that particular color in the spectrum which is considered by authorities as the reddest red, the greenest green, the bluest blue,' etc. These discs were one-half inch in diameter and were mounted on white cards $1\frac{1}{2} \times \frac{3}{4}$ inches. In addition to the color discs there were record blanks on which each subject recorded name, sex, age, date, name of school, and, in case he was an Indian, his tribe with degree of Indian blood.

The Procedure

It was very clearly explained to the subjects that record blanks were to be passed to them and on these they were to give the desired information called for as to age, sex, etc. After this part of the procedure had been carried out they were next told that it was desired to find out just what colors they liked best of the ones to be found in the little envelopes about to be distributed. When these had been distributed, one to each subject, instructions were then given that each individual should throw out all the colors contained in his envelope, on the top of his desk. Then it was said that each individual should select the color out of the seven that he liked best and place it on the record blank opposite the '1'; the one he liked next best he should place just below it and opposite the '2' on the record blank; and the one he liked third best was to be placed under that and opposite the '3,' etc., and after all the colors had been arranged, which would of course make the one liked least of all come last and that would be opposite the '7,' they were to write the name of each color beside the color itself on the record blank before disturbing their orders of preference. Then it would be expected of them that they place the colors—all seven of them—back in the envelopes. But care was taken to see that each subject followed these instructions and also that there was no suggestion of any kind on the part of the experimenter or his assistants as to what the individual's color preference should be.

Handling of the Data

The record blanks gave the information desired and the data so obtained were tabulated with due regard for classification with reference to race, sex and education.

In the full-blood Indian group there were of both sexes and all ages ranging from 11 to 21 years, as we have said, 559 cases. This makes a homogeneous group and is sufficiently large for our purposes. The question now is as to how we shall go about determining the order of preference for these colors which obtains in this large group of Indians. The tabulation referred to above which is the first draft of the material, by way of illustration, looks something like the following:

Boys—Fourth Grade—Rankings Given the Colors

Subject No.	1	2	3	4	5	6	7	8	9	10	11	12, etc.
Age Yrs.	11	11	12	12	12	12	13	13	13	13	13	14
Rank given:												
Red	1	1	2	1	2	5	3	1	6	3	2	2
Blue	3	3	1	2	3	1	1	2	3	1	1	1
Green	2	4	3	4	1	3	2	4	4	4	3	3
Purple	4	2	5	3	4	2	4	3	1	2	5	4
Orange	5	6	4	5	6	4	5	5	2	5	4	5
Yellow	6	5	6	6	5	7	6	7	5	7	6	6
White	7	7	7	7	7	6	7	6	7	6	6	7

In order to find out the order of preference existing in the data in this first tabulation and to bring same to light, we may do two things: (1) simply average the ranks given to any color, calculate the A.D. and P.E., find the median of the ranks, and having done this for all the colors proceed to arrange our colors according to the ranks of these averages and medians, determining the reliabilities of the differences according to the accepted formula for same; and (2) we may construct a scale of color preference for Indians such as Thorndike constructed for handwriting and Hillegas made for English composition. (See *Teachers College Record*, Vol. II., No. 2, and Vol. XIII., No. 4.)

Both of these methods have their advantages. The first

gives us a rough idea of the tendencies of the data and permits of the use of measures of overlapping which is a matter of importance here; the second will make possible the determination of the preferential value of any color under the experimental conditions and permits of a graphic representation of the relative positions which may be assigned to the several colors on a scale of preference.

The Color Preference of Indians

Availing ourselves of both methods, we begin with the first of them, as: Table I. gives the average and median

Table I

Showing Central Tendencies and their Ranks of Group of 559 Full-Blood Indians in Judging Seven Colors

Ranks of	Ave.	A.D.	P.E.	Med.	Ave.	Med.	Per Cent. Attaining and Exceeding Median of Preceding Color
Red	2.5	1.04	.8	2.5	1	1	
Blue	3.02	1.4	1.1	3.3	2	2	(Red) 67
Violet	3.6	1.7	1.4	8.9	3	3	(Blue) 62
Green	4.09	1.1	.8	4.7	4	4	(Violet) 64
Orange	4.7	1.3	1.1	5.3	5	5	(Green) 65
Yellow	5.2	1.2	.9	6.1	7	6	(Orange) 66
White	4.9	1.8	1.5	6.5	6	6	(Yellow) 52

position assigned to the seven colors by the 559 full-blood Indian subjects as well as the sequence of the colors as indicated by the ranking of these. It gives also the overlapping, or measure of per cent. of judgments, of a color attaining and exceeding the median assigned to the color just preceding it. This latter figure indicates whether or not the several sequences as indicated by the respective medians are supported by a fact of difference between them, *i.e.*, as to whether or not they are representative and if not exactly representative whether or not they tend to be so. It will be seen that in this group of full-blood Indians the sequence of the preference for these colors is this, going from most preferred to least preferred: First, Red; Second, Blue; Third, Violet; Fourth, Green; Fifth, Orange; Sixth, Yellow and White. That is, the situation of White and Yellow is undetermined by this handling of the data. The sequence, shown in Table I.,

tends to be representative where such a sequence is indicated, as tested by the overlapping, with a slight advantage for the Yellow over White; however this advantage is barely evident.

But this method fails to give us all the facts afforded by the data, for we want to know how much stronger as measured is the preference value of one color than another as reckoned from a common reference point. It is just here that this experiment claims to be different in method from other color preference experiments and experiments for determining the relative 'pulling power' of similar given stimuli. We do not feel that this is the place for a discussion of the relative merits of either method of procedure, but we recommend its use for the purpose of measuring the relative strengths of colors, 'selling points,' advertisements, and similar material.

A Color Preference Scale

It may not be necessary to describe the derivation of a judgment scale such as that of Thorndike in his Handwriting Scale and that of Hillegas in his Scale for the Measurement of Quality in English Composition and the writer's Scale for Measuring Method of Study of College Students (see *Pedagogical Seminary*, Mar., 1920), but some account of the method of handling this particular mass of data for determining color preference of Indians may be more or less worth while. It was simply a matter of finding how many times out of 559 one color was placed above the other. Table II.

Table II

Showing Number of Times One Color Was Preferred to Another by the Group of 559 Full-blood Indians

The table reads thus: White was preferred to White never, to Yellow 268 times, to Orange 243 times, etc., out of 559.

	White	Yellow	Orange	Green	Purple	Blue	Red
White	0	268	243	221	208	155	78
Yellow	291	0		147	143	113	79
Orange	316	361	0	224	183	128	97
Green	338	412	335	0	220	180	149
Purple	351	417	376	339	0	229	184
Blue	404	446	431	379	330	0	219
Red	481	480	462	410	375	340	0

shows this for all colors, as Red was preferred to Blue by 340 out of the 559 pure-blood Indians; Red was preferred to

Purple by 375 out of the 559, was preferred to Green by 410. Yellow was preferred to White by 291 out of the total 559. Since this last was only 53 per cent. of the time, it had practically little advantage over White. Table III. shows what per cent. of the subjects preferred any color above another.

TABLE III

NUMBERS OF TABLE II. EXPRESSED AS PERCENTAGES OF TOTAL JUDGMENTS

To be read: White was preferred to Yellow 47 per cent. of the time, to Orange 43 per cent. of the time, to Green 39 per cent. of the time, etc.

	White	Yellow	Orange	Green	Purple	Blue	Red
White	0	47	43	39	37	28	14
Yellow	53	0	35	26	25	20	15
Orange	56	64	0	40	33	23	17
Green	60	73	60	0	39	32	27
Purple	63	74	67	60	0	41	33
Blue	72	79	77	67	59	0	39
Red	86	85	82	73	67	61	0

The next step in deriving a scale of color preference is to take the facts of Table III. and arrange the seven colors in sequence running from least preferred to most preferred and having done this to transmute the necessary percentages into values of D/M.D. by using the table given on pages 24 and 25 of Hillegas' 'A Scale for Measurement of Quality in English Composition' which was derived from a table found in Thorndike's 'Mental and Social Measurements,' page 228.

The reason for using White at all was with the expectation that, since it is achromatic, it would prove to be a zero point in color preference. But it did not serve the purpose of an absolute zero point, so we took it as an *arbitrary* zero point, and upon that constructed our scale. The differences as expressed in terms of Difference divided by Median Deviation for the several colors are these:

Color		Color	Per Cent. of the Time	D/M.D.
Red	preferred to	Red	0	—
Blue	"	" Red	39	.41
Violet	"	" Blue	41	.34
Green	"	" Purple	39	.41
Orange	"	" Green	38	.40
Yellow	"	" Orange	35	.57
White	"	" Yellow	47	.11

This gives the following scale values:

Color	Value
White	.00
Yellow	.10
Orange	.68
Green	1.08
Violet	1.49
Blue	1.83
Red	2.24

It will be seen that for this group of Indians, there are fairly definitely established preferences for the several colors which stand at almost equal distances on the scale. Violet has more than twice the value of Orange. Red is most preferred of all. It is twenty times as strong as Yellow, three times as strong as Orange, one and one half times as strong as Violet, and one and one fourth times as strong as Blue. Taking Yellow as a base, we have approximately these proportions:

Yellow	Orange	Green	Violet	Blue	Red
1	6	9	13	16	20

This sequence represents a series in arthmetical progression after leaving Yellow. These observations and all those following hold only for the data in hand. We do not know whether or not more data from individuals of such racial stocks as represented here would change the above sequence, however since the group is rather large, it seems to the experimenter probable that this would not change materially the results.

While the above scale gives the order of preference of the seven colors as obtained from the 559 full-blood Indians, the accompanying chart (Fig. 1) gives a graphical representation

A Graphic Representation of Color Preference Scales Showing Positions Assigned the Colors as Determined by

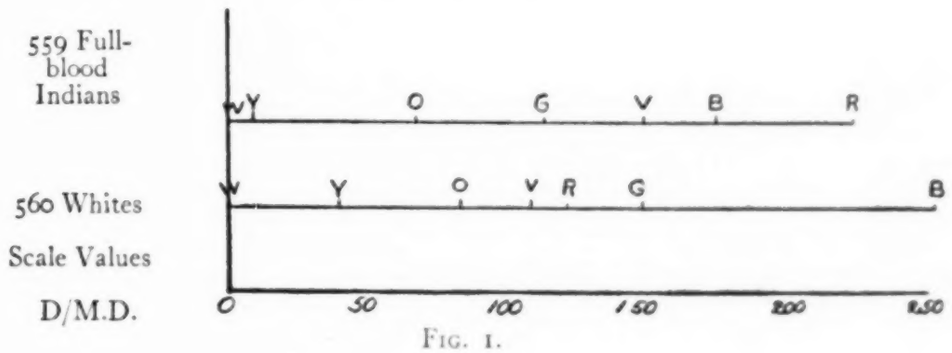

Fig. 1.

of this. In addition there is likewise a graphic representation for a group of white subjects similarly constructed. At the bottom of the chart the values of various points on a scale thus constructed are given. On the line above these we give the positions as derived for the colors on this scale for the group of 559 full-blood Indians.

So much for the sequence of the colors, the reliability of the differences between the members of the sequence and their relative values on a color preference scale for the full-blood Indians. The sequences as indicated tend to be real with the exception of the sequence: Yellow followed by White. The relative preferences of the colors are indicated on the scale.

The Influence of Education on Color Preference in Indians

The second problem which we wish to attack after finding a satisfactory sequence of color preferences for our original group of Indians, is stated in the question: Are the color preferences, here indicated, native or acquired? Unfortunately we are not able to go below the fourth grade in the matter of education with our subjects, for all of them had that much school training in the United States Indian schools. And since we cannot go below that in the present case, we shall have to grant that they possessed the nearest approach to native preference our data offers.

We shall, then, take the color preferences of these subjects as a basis of comparison with the color preferences of students of grades higher up. In order to make this study of the influence of education we have made a division of our 559 subjects on a basis of school grades which gives us five subgroups, starting with the fourth grade, whose compositions are as follows:

Grade	Number
Fourth	113
Fifth	121
Sixth	117
Seventh	106
Eighth, Ninth, Tenth	102
Total	559

The same measures found for the full bloods in the total group, were found for the educational subgroups into which we have divided it, *i.e.*, averages, medians, measures of overlapping. Table IV. contains an array of these measures and

TABLE IV

SHOWING CENTRAL TENDENCIES AND THEIR RANKS FOR SEVERAL GRADE SUBGROUPS OF FULL-BLOOD INDIANS

Color	Ave.	A.D.	P.E.	Med.	Ave.	Med.	Per Cent. Attaining and Exceeding Median of Preceding Color
Fourth Grade—113 Judges							
Red	2.6	1.4	1.2	2.6	1	1	
Blue	3.1	1.1	.9	3.5	2	2	(Red) 73
Green	3.4	1.7	1.4	3.7	3	3	(Blue) 57
Violet	4.3	1.9	1.6	4.6	4	4	(Green) 64
Orange	4.8	1.1	.9	5.3	6	6	(Yellow) 50
Yellow	4.5	1.3	1.0	5.3	5	5	(Violet) 66
White	4.0	1.3	1.1	6.0	7	7	(Orange) 62
Fifth Grade—121 Judges							
Red	2.2	1.0	.8	2.1	1	1	
Blue	3.1	1.3	1.0	3.1	2	2	(Red) 89
Violet	3.6	1.6	1.3	4.0	3	3	(Blue) 68
Green	4.2	1.6	1.3	4.9	4	4	(Violet) 63
Orange	4.3	1.3	1.0	5.2	5	5	(Green) 59
Yellow	4.4	.8	.7	6.2	6	7	(White) 57
White	4.8	1.8	1.5	6.1	7	6	(Yellow) 49
Sixth Grade—117 Judges							
Red	2.1	.9	.7	2.1	1	1	
Blue	3.1	1.7	1.4	2.8	2	2	(Red) 79
Violet	3.5	1.5	1.2	4.1	3	3	(Blue) 72
Green	4.4	1.1	.9	5.1	4	4	(Violet) 71
Orange	4.7	1.4	1.1	5.3	5	5	(Green) 58
Yellow	5.4	1.0	.8	6.2	7	7	(Orange) 51
White	4.8	1.8	1.5	6.1	6	6	(Yellow) 48
Seventh Grade—106 Judges							
Red	2.4	1.2	.9	2.5	1	1	
Blue	3.2	1.3	1.1	3.6	2	2	(Red) 75
Violet	3.4	1.6	1.3	3.8	3	3	(Blue) 55
Green	4.4	1.2	1.0	5.1	4	4	(Violet) 77
Orange	4.5	1.3	1.1	5.5	5	5	(Green) 63
Yellow	5.2	1.2	.9	6.1	7	6	(Orange) 63
White	4.3	1.8	1.5	6.1	6	6	(Yellow) 50
Eighth, Ninth, and Tenth Grades—102 Judges							
Red	2.1	1.3	1.1	3.1	1	1	
Blue	2.8	1.3	1.1	3.1	2	1	(Red) 50
Violet	3.2	1.5	1.2	3.5	3	2	(Blue) 58
Green	3.9	1.5	1.2	4.4	4	3	(Violet) 66
Orange	4.5	1.2	.9	5.2	5	4	(Green) 73
Yellow	5.6	1.1	.9	6.5	7	5	(Orange) 76
White	4.9	1.7	1.4	6.5	6	5	(Yellow) 50

the orders of sequence of the colors for each educational subgroup.

While the sequences are not exactly the same, there is very little change in that respect as we proceed from the fourth grade sequence of color preference to the highest school grade sequence.

In the fourth grade the sequence is Red, Blue, Green, Violet, Yellow, Orange, White. In the fifth grade almost the same sequence obtains for averages and medians excepting for the Green and the last three colors, in which the results for averages and medians do not coincide for Yellow and White. While they do in the next higher grade, the sixth, where Yellow goes to the lower end of the scale, they do not in the seventh grade sequence. This contest between Yellow and White may be seen ending up in the highest educational group with White and Yellow about even, but Green never recovers its lost prestige. Red is always in the ascendancy excepting in this last group where the median shows Blue occupying the same rank with it. It should be noted that the measures of overlapping are usually sixty per cent. and above. The table will indicate the cases in which this measure is or is not approaching significance. The conclusion to be reached here is that education from the fourth grade up has very slight effect on the sequence of color preferences of full-blood Indians as indicated by this method of handling the data, though it is true that Blue and Violet tend to move up toward the position given Red—*i.e.*, first place; and White tends to displace Yellow in a few instances.

In order to determine the reliability of the differences in color preference, if any is to be found in moving up the grades, measures of overlapping of the distribution of each grade were obtained on the Fourth Grade distribution as a base. This is shown in Table V. If there is any difference its tendency may be thus measured. As for instance, the facts of this table bear us out in saying that Red experiences no change throughout the grades until we reach the last grade group—that of 8th, 9th, and 10th grades, where the overlapping on the fourth grade is significant. The overlapping is sig-

nificant again in 6th grade for Blue where that color's ranking was better than was the same color's ranking in the 4th grade—*i.e.*, was more preferred. But the overlapping for

TABLE V

SHOWING OVERLAPPING OF SUCCESSIVE SCHOOL-GRADE DISTRIBUTIONS ON THAT OF FOURTH GRADES FOR EACH COLOR FOR FULL-BLOOD INDIANS

	Fourth Grade Medians	Overlapping for 4th Grade on			
		Fifth Grade	Sixth Grade	Seventh Grade	8th–10th Grades
Red	2.6	45%	44%	50%	63%
Blue	3.5	49	36	56	54
Violet	4.6	42	45	37	31
Green	3.4	70	79	79	63
Orange	5.3	49	54	59	51
Yellow	5.3	72	73	68	74
White	6.0	52	52	54	51

TABLE V*a*

SHOWING AGES OF FULL-BLOOD INDIANS FOR EACH EDUCATIONAL SUBGROUP

	Fourth Grade	Fifth Grade	Sixth Grade	Seventh Grade	8th–10th Grades
Ave.	14.5 yrs.	15.4 yrs.	16.2 yrs.	17.7 yrs.	18.5 yrs.
A.D.	2.4	1.6	1.5	1.7	1.8
P.E.	2.0	1.3	1.2	1.2	1.4

that color is not significant elsewhere, not even in the highest grades. The situation with respect to Violet and Green reveals this, that the overlapping for Violet becomes significant (see table) in the 7th grade and increases in significance in the highest grade and that Green shows significant differences in the grades above the 4th, but it is not of a constantly increasing significance. This is likewise true of Yellow. In all, these measures of overlapping indicate that no great change of an increasing nature is brought about in color preference by education except in the case of Violet and Red. Violet increases and Red loses in preference.

COLOR PREFERENCE SCALES FOR EDUCATIONAL SUBGROUPS

As in the case of the group of 559 proper we have derived separate scales for the educational subgroups for the purpose

of comparison of 'pull' of colors in the grades. These scales and their graphic representation are given here in Table VI.

TABLE VI

COLOR PREFERENCE SCALES FOR EDUCATIONAL SUBGROUPS—FULL-BLOOD INDIAN CHILDREN

Fourth Grade

Color	Scale Value
White	.00
Yellow	.41
Orange	.48
Violet	.67
Green	1.05
Blue	1.31
Red	1.84

Fifth Grade

Color	Scale Value
Yellow	.00
White	.04
Orange	.23
Green	.57
Violet	.95
Blue	1.36
Red	2.01

Sixth Grade

Color	Scale Value
Yellow	.00
White	.07
Orange	.29
Green	.51
Violet	1.25
Blue	1.90
Red	2.35

Seventh Grade

Color	Scale Value
White	.00
Yellow	.11
Orange	.52
Green	.59
Violet	1.37
Blue	1.44
Red	1.88

Eighth, Ninth, and Tenth Grades

Color	Scale Value
White	.00
Yellow	.26
Orange	1.26
Green	1.60
Violet	2.09
Red	2.39
Blue	2.46

and Fig. 2 (which gives the graphic representation of similarly treated white groups each of about the same size as these Indian groups). The scales only and not the tables from which they were derived are given here for the sake of economizing space.

As we derived these scales for the grade groups, five in number, for fourth, fifth, sixth, seventh grades, each a scale, and one scale for eighth, ninth, and tenth grades combined in one, we discovered that our original arbitrary zero point, the achromatic White, which served very well in the large scale for full bloods had shifted very slightly in two of the educational subgroups, *i.e.*, in the fifth and sixth grades. That is to say, White was preferred to Yellow in both of these educational groups, but it found its place below the Yellow again in the last two of the educational subgroups, the seven thand the 8th–9th–10th grade subgroups. We cannot account for this and do not wish to speculate to any extent on its significance. If it has any significance in being preferred to Yellow, in these two instances that significance is

very slight, and this may lie in the fact that the contest of Yellow with the other chromatic samples was so great that it overshadowed the contest of these with just no color, White. It will be observed that Red maintains its position as most preferred in all the educational subgroups until we

A Graphic Representation of Color Preference Scales Showing Positions of Colors for Various Educational Groups of Whites and Full-blood Indians

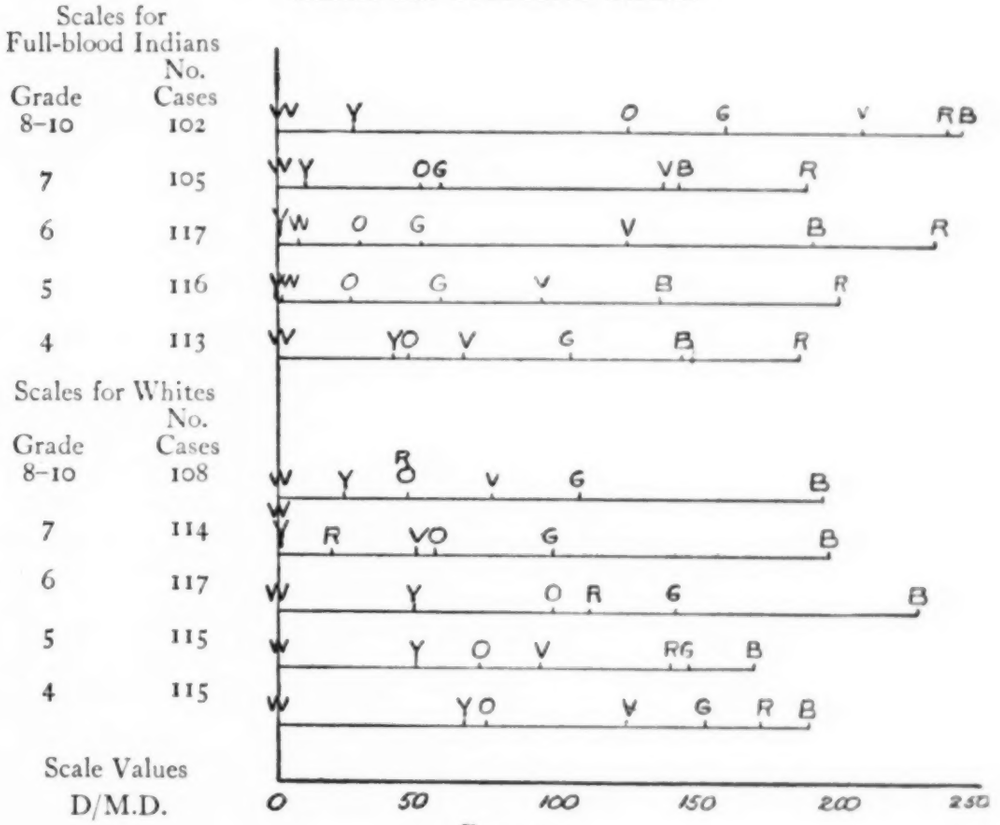

Fig. 2.

come to the most educated subgroup where it barely succumbs to a slight preference for Blue, when we examine the chart and the accompanying scales for each grade subgroup.

Red starts in the fourth grade subgroup with four times the preference given to Yellow and shows nearly nine times that of Yellow in the last two most educated subgroups. In its contest with Violet, it loses some of its 'pull' over that color, starting with three times and ending up with one and one tenth times the 'pull' it had over that color. It starts with a 'pull' equal to one and one half times that of Blue and is slightly inferior in 'pull' to it in the most educated group.

Since the factor of age has been to a certain extent controlled along with education (See Table V*a*.) no detailed study of that factor will be made here. On the average age increases with education.

Sex Differences in Color Preference among the Indians

A question arises as to what influence sex has on the color preferences of the full-blood Indians. An examination of the literature shows that no striking sex differences obtain for whites. Jastrow found a masculine tendency to prefer Blue for first place and Red for second, and a feminine tendency to place Red first and Blue second (2, 3).

In order to answer the question as to whether there is a sex difference among the subjects representing full-blood Indians we have separated our 291 males from our 268 females and found for the two sex groups the facts as represented in Tables VII. and VIII., which give the sequences of averages

Table VII

Showing Central Tendencies and Sequences of Positions Assigned to the Colors by Males and Females of Full-blood Indians

I. *For Males, 291 Cases*

Color	Ave.	A.D.	P.E.	Med.	Rank of:		Per Cent. Attaining and Exceeding Median of Preceding Color
					Ave.	Med.	
Red	2.4	1.7	1.3	2.5	1	1	
Blue	3.4	.9	.7	3.3	2	2	(Red) 79
Violet	3.5	1.8	1.4	3.8	3	3	(Blue) 58
Green	8.9	1.6	1.3	4.5	4	4	(Violet) 61
Orange	4.5	1.0	.8	5.2	5	5	(Green) 67
Yellow	5.0	1.1	.9	5.8	6	6	(Orange) 64
White	5.0	2.0	1.6	6.3	6	7	(Yellow) 59

II. *For Females, 268 Cases*

Red	2.4	1.2	.9	2.3	1	1	
Blue	2.6	1.3	1.0	2.7	2	2	(Red) 62
Violet	3.6	1.3	1.0	4.1	3	3	(Blue) 77
Green	4.3	1.2	.9	5.0	4	4	(Violet) 69
White	4.6	2.0	1.6	5.4	5	5	(Green) 59
Orange	4.8	1.1	.9	5.4	6	5	(Green) 62
Yellow	5.5	1.3	1.0	6.5	7	6	(Orange) 70

and medians and the overlapping of one color distribution over the preceding one in the sequence. Also we have derived color-preference scales for the sex groups which accompany these tables. As to the sequences, they are more or less definite for the sex groups and are practically the same for the males and females with this exception, that the females place White above Yellow and equal in 'pull' to Orange, the males placing it last. The experimenter thinks he can account in part for this high rating of White on the part of the females by the fact of recency, since at the time the experiment was administered the older female students were preparing for graduation and he was warned of this fact by the teacher of domestic science in one of the schools. For that reason it is only in all probability a temporary tendency which spread from the older students down the grades. This is supported by the fact that the lower grade students tend to place White lower in the scale than do the older students of this sex.

TABLE VIII

SHOWING OVERLAPPING OF POSITIONS ASSIGNED BY MALES ON FEMALE DISTRIBUTION

Per Cent. of Male Judgments Attaining and Exceeding Median of Female Median Position for Each Color

Red	52
Blue	76
Violet	48
Green	41
Orange	49
Yellow	37
White	61

TABLE VIII*a*

SCALE VALUES FOR MALE AND FEMALE INDIAN COLOR PREFERENCE

Males (291)		*Females (265)*	
Color	Scale Value	Color	Scale Value
White	.00	Yellow	.00
Yellow	.45	White, Orange	.74
Orange	.86	Green	1.05
Green	1.24	Violet	1.62
Violet	1.43	Blue	2.36
Blue	1.47	Red	2.56
Red	2.67		

An examination of the facts of Table VIII shows a tendency for the males to place Blue lower than females, and Yellow higher and White lower, since the overlapping for the

first is 76 per cent. and for the last two colors is respectively 37 per cent. and 61 per cent. However this difference with respect to the first color, Blue, does not alter the sequence in that instance. It merely indicates that the females esteem Blue more highly than do the males, but not to the extent of placing it above Red. An examination of the two color preference scales for the two sexes bears us out in this statement for if we should eliminate White from the males' scale entirely the scale value for Blue would be 1.02 and examination of the females' scale shows that Blue has a preference value of 2.36. The two scales for the sexes show other interesting features as Orange has nearly twice the scale value (eliminating White from the scale) for the females as it has for the males and under the same conditions rather less value with the males than it has for the females as have all the colors. Still these sex differences do not alter the race sequences of the color preferences, we believe.

Racial Differences in Color Preference

In order to answer the third question as to whether or not these full-blood Indians differ from mixed bloods and whites in their color preferences, we shall compare *first*, tendencies of the racial groups and their differences, and, *second*, the color preference scales for these groups. Only in the case of the whites shall we study the influence of education on these representatives of that race, and bring the facts so derived to bear on the array of facts obtained in the previous study of the influence of education on the Indians. This will not be possible in the case of the mixed bloods because of the fact, noted above, of the inadequacy of the number of individuals in this group.

Tables IX. and X. show the averages and medians of the positions assigned to the colors by the group of 174 mixed bloods and by the group of 560 whites as well as the ranks of these averages and medians. Table XI. shows the white group broken up into educational subgroups corresponding to those of the full bloods.

An examination of these various measures will show for

TABLE IX

SHOWING CENTRAL TENDENCIES AND THEIR RANKS OF GROUP OF 174 MIXED-BLOOD INDIANS IN JUDGING COLORS

Color	Ave.	A.D.	P.E.	Med.	Ave.	Med.	Per Cent. Attaining and Exceeding Median of Preceding Color
Red	2.7	1.0	.5	3.01	2	2	(Blue) 56
Blue	2.6	1.2	.6	2.8	1	1	
Violet	3.6	1.6	.8	4.2	3	3	(Red) 62
Green	4.4	1.4	.6	4.9	5	4	(White) 66 or (Violet) 66
Orange	5.1	1.0	.5	5.7	6	5	(Green) 72
Yellow	5.3	1.3	.6	6.2	7	6	(Orange) 62
White	4.1	1.7	.7	4.2	4	3	(Violet) 50

TABLE X

SHOWING CENTRAL TENDENCIES AND THEIR RANKS OF GROUP OF 560 WHITES IN JUDGING COLORS

Color	Ave.	A.D.	P.E.	Med.	Ave.	Med.	Per Cent. Attaining and Exceeding Median of Preceding Color
Blue	2.2	1.1	.9	2.2	1	1	
Green	3.4	1.3	1.0	3.8	2	2	(Blue) 83
Red	3.8	1.7	1.4	4.2	3	3	(Green) 51
Violet	3.9	1.2	.9	4.6	4	4	(Red) 60
Orange	4.4	1.2	1.0	5.1	5	5	(Violet) 61
Yellow	4.7	1.3	1.0	5.6	6	6	(Orange) 61
White	4.9	1.7	1.5	6.3	7	7	(Yellow) 60

the mixed bloods and for whites, sequences different from that of full bloods, as:

	Rank						
	1	2	3	4	5	6	7
Full Bloods	Red	Blue	Violet	Green	Orange	Yellow	White
Mixed Bloods	Blue	Red	Violet	White	Green	Orange	Yellow
Whites	Blue	Green	Red	Violet	Orange	Yellow	White

Blue and Red are scarcely different for mixed bloods and in the case of whites, Red and Green are so nearly alike that any discrimination will be more or less arbitrary. The reliability of the several sequences as representing real differences may be observed by examining the above designated tables.

It will be necessary now to measure the overlapping of the positions on the scale assigned to the colors by the different racial groups. (See Table XI.)

TABLE XI

A. SHOWING THE OVERLAPPING OF FULL-BLOOD INDIANS ON MIXED BLOOD AND WHITE MEDIANS FOR POSITIONS OF EACH COLOR

Color	Per Cent. of Full-blood Judgments Attaining Median Position Assigned by: 174 Mixed Bloods	560 Whites
Red	39	23
Blue	63	83
Violet	47	41
Green	48	66
Orange	43	59
Yellow	51	58
White	68	51
Range	39–68	23–83

B. SHOWING THE OVERLAPPING OF FULL-BLOOD INDIANS ON MEDIAN OF WHITES FOR EACH GRADE GROUP

	Per Cent. of Full-blood Indian Judgments Attaining and Exceeding Medians for Positions of Each Color: Fourth Grade	Fifth Grade	Sixth Grade	Seventh Grade	8th–10th Grades
Red	38	26	14	12	11
Blue	74	76	71	79	56
Violet	51	40	35	21	33
Green	43	63	77	72	67
Orange	64	51	29	63	59
Yellow	50	69	62	61	67
White	34	43	48	54	50

Now if the measures of overlapping of full bloods over whites and mixed bloods may be taken as indicating tendencies toward real differences in the groups, we may say that these comparisons of the blood groups show that for each color there is more tendency toward real difference in color preference between full bloods and whites than between full bloods and mixed bloods because the measures of overlapping are on the whole more significant for full bloods on the white than on the mixed-blood distribution. The overlapping in the former case runs from 23 per cent., in the case of Red, to 83 per cent., in the case of Blue, and is smallest in the case of White, 51 per cent. That is, the differences in preference for Red and Blue are real for the groups—full

bloods and whites—and are very much alike for White, Violet, and Yellow. As to the overlapping of full blood on mixed-blood distribution, this runs from 39 per cent. in the case of Red to 68 per cent. in the case of White, with that of Blue 63 per cent. There is more tendency to difference in the case of White than in the case of Blue and Violet, here.

Color Preference Scales for Whites and Mixed Bloods

So much for the determination of indicated racial group differences, but we believe that insofar as the comparison of white and full-blood Indian color preference is concerned, it will be more definitely represented by a comparison of the color preference scales. In the case of the mixed-blood scale, such comparisons are not nearly so legitimate, because of the disparity of the number of subjects, here only 174 in the mixed-blood group, while there are 560 whites and 559 full bloods.

Color preference scales for the 174 mixed bloods and the 560 whites were constructed in the same way that such scales were made for the full-blood Indians. These are given below. Figure 1 affords a graphic representation of the white scale along with that of the full-blood scale, and Figure 2 gives this for the mixed-blood scale. These comparisons are permissible: The white subjects gave to Yellow four times the

Color Preference Scale for Whites—560 Judges

Color	Scale Value
White	.00
Yellow	.41
Orange	.82
Violet	1.08
Red	1.23
Green	1.49
Blue	2.49

Color Preference Scale for Mixed-blood Indians—174 Judges

Color	Scale Value
Yellow	.00
Orange	.30
Green	.75
White	.94
Violet	1.01
Red	1.46
Blue	1.53

value given it by the Indians, reckoning from White as a point of reference. To Orange, they give about the same, according it only slightly more preference. Violet has more 'pull' for the Indians than it does for the whites, while Green 'pulls' harder on the latter than on the former, something like a third more, if we may express these relations in terms of scale positions. Further, Red is esteemed nearly twice as much by the Indians as by the whites, and Blue has something like three fifths of the value for them that it has for the whites.

Because of the smaller group, 174 judges, deriving the Mixed-blood Scale, we do not feel disposed to make very definite comparisons between it and those for the full bloods and whites. But if the scale as it stands had been derived by a group of judges of the same size as the other racial groups we could say, taking Yellow as a reference point in all scales, that the mixed bloods have somewhat less regard for Orange than the whites and much less than the full bloods. The 'pull' of Green, and the 'pull' of Orange stand in about the same ratio with them, that they do with the whites. This is likewise true of Blue and Orange. But they are more like the full bloods when the 'pulling powers' of Violet and Red are taken in relation to Orange. However, we only suggest by this what might be ascertained if the group of mixed bloods were equal in size to that of the other racial groups.

Comparison of Influence of Education on Whites and Indians

We have not yet finished the discussion of racial differences in color preference, for the data affords other possibilities still. We have noted that the sequence of color preferences of full-blood Indians changes only slightly with education if we may take the groups as representative of full-blood Indians. Is this so with the whites? We have seen that the median positions assigned to the several colors by a race group differ in many points for the large groups of whites and Indians as measured by overlapping of Indian

distribution on the white distribution. Do these tendencies to differ exist in the educational subgroups? Or does education tend to eliminate these differences? We have observed the tendency for a few colors to change in relation to 'pulling power' as education increases with the full-blood Indians. How does this fall out for the whites? In fact, these, and many other questions may be asked in this connection.

Table XII. gives the central tendencies of positions assigned to the colors by the whites of various grade subgroups, their sequences and the tendencies toward real differences for the colors in a designated sequence. The tables show that Red tends to lose in preference value with education and Green to gain. This is not supported by the findings of some other investigations. See Winch (1). Green starts with third place in the fourth grade, and gains second place in the sixth grade, and maintains this position, while Red falls to fourth place, in this last educational subgroup, from that of second place in the first two grade subgroups. Otherwise there is practically little change in the sequence as found in going from one grade group to the other for the white judges. This is quite different in the case of the full bloods where Green instead of gaining fell away early in the grades and Red tended to remain first instead of falling as it did with the whites. Violet displaces Red for the whites in the most educated white subgroup, but, though it encroaches on it, it never displaces that color in the educational subgroups of full-blood Indians.

Table XIII. shows scales derived for the educational subgroups of whites. Fig. 3 offers a graphic representation of

A Graphic Representation of Color Preference Scale for 174 Mixed-blood Indians

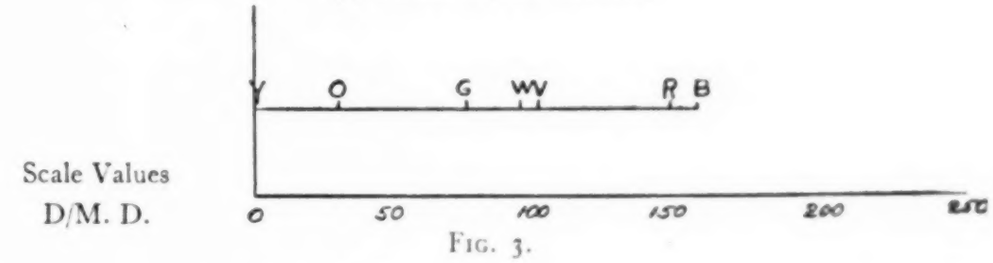

Fig. 3.

the same scales. As to the comparative effect of education

TABLE XII

SHOWING CENTRAL TENDENCIES AND THEIR RANKS FOR SEVERAL EDUCATIONAL SUBGROUPS OF WHITES

Fourth Grade—115 Judges

Color	Ave.	A.D.	P.E.	Med.	Ave.	Med.	Per Cent. Attaining and Exceeding Median of Preceding Color
Blue	2.8	1.1	1.0	2.5	1	1	
Green	3.6	1.4	1.1	4.0	3	3	(Red) 72
Red	3.3	1.8	1.4	3.2	2	2	(Blue) 65
Violet	4.0	1.5	1.2	4.5	4	4	(Green) 60
Orange	4.4	1.3	1.2	5.1	5	5	(Violet) 66
Yellow	4.6	1.4	1.2	5.4	6	6	(Orange) 60
White	5.5	1.6	1.4	6.1	7	7	(Yellow) 70

Fifth Grade—115 Judges

Blue	2.2	1.1	.9	2.3	1	1	
Green	3.54	1.4	1.2	4.0	3	3	(Red) 59
Red	3.51	1.6	1.2	3.8	2	2	(Blue) 79
Violet	4.1	1.4	1.1	4.6	4	4	(Green) 64
Orange	4.6	1.4	1.1	5.3	5	5	(Violet) 66
Yellow	4.7	1.6	1.2	5.4	6	6	(Orange) 62
White	5.3	1.6	1.2	6.7	7	7	(Yellow) 66

Sixth Grade—117 Judges

Blue	1.9	1.0	.8	2.0	1	1	
Green	3.5	1.9	1.5	3.8	2	2	(Blue) 89
Red	3.8	1.5	1.2	4.2	3	3	(Green) 59
Violet	4.1	1.4	1.2	4.6	4	4	(Red) 63
Orange	4.9	1.3	1.0	6.3	5	6	(Yellow) 45
Yellow	5.0	1.1	.9	5.9	6	5	(Violet) 77
White	4.9	1.3	1.0	6.3	5	6	(Yellow) 56

Seventh Grade—105 Judges

Blue	2.0	.9	.8	2.1	1	1	
Green	3.4	1.4	1.2	4.0	2	2	(Blue) 83
Red	4.3	1.7	1.4	4.9	4	3	(Green) 66
Violet	4.2	1.4	1.1	5.0	3	4	(Red) 51
Orange	4.3	1.3	1.0	4.9	4	3	(Green) 70
Yellow	4.8	1.4	1.0	5.7	6	5	(Violet) 59
White	4.5	1.7	1.5	5.8	5	6	(Yellow) 52

Eighth, Ninth, and Tenth Grades—108 Judges

Blue	2.1	1.1	.9	1.9	1	1	
Green	3.3	1.4	1.1	3.3	2	2	(Blue) 84
Red	4.3	1.6	1.2	4.9	4	4	(Violet) 57
Violet	3.9	1.4	1.1	4.5	3	3	(Green) 73
Orange	4.3	1.4	1.1	4.9	5	4	(Violet) 57
Yellow	4.9	1.3	1.0	5.9	6	5	(Red) 65
White	5.1	1.7	1.5	6.1	7	6	(Yellow) 65

on the relative 'pull' one color has over another in the two races we noted for the full-blood Indians that Red increases its 'pull' over Yellow, nearly doubling its effect with increase

TABLE XIII

COLOR PREFERENCE SCALES FOR EDUCATIONAL SUBGROUPS—560 WHITE CHILDREN

Fourth Grade

Color	Scale Value
White	.00
Yellow	.65
Orange	.74
Violet	1.22
Green	1.52
Red	1.71
Blue	1.90

Fifth Grade

Color	Scale Value
White	.00
Yellow	.53
Orange	.72
Violet	.94
Red	1.39
Green	1.44
Blue	1.71

Sixth Grade

Color	Scale Value
White	.00
Yellow	.49
Orange	.98
Violet, Red	1.09
Green	1.39
Blue	2.39

Seventh Grade

Color	Scale Value
White, Yellow	.00
Red	.19
Violet	.49
Orange	.56
Green	.97
Blue	1.97

8th, 9th, and 10th Grades

Color	Scale Value
White	.00
Yellow	.22
Red, Orange	.48
Violet	.78
Green	1.08
Blue	1.94

of education for the subjects considered, but with the whites, Red loses in relative 'pull' over Yellow; as in the fourth grade it is nearly three times as strong as Yellow, but in the last grade subgroup it is twice as strong only. This is due to the fact that Red was a diminishing factor all along the above mentioned grade scales. The Red started with the whites with a 'pull' one and one half times that of Violet, and ends up with a little more than half the 'pull' of Violet. The fact is, Red always 'pulls' harder in the Indian Scale relatively, as compared with Violet, than it does in the white Scale. The situation of relative 'pull' of Red and Blue as influenced by education, thus indicated, is this for the two races: for Indians, in term of 'pull' for the lowest grade, Red is to Blue as 100 is to 71, but in the highest grade subgroup it is 100 to 102; and for whites, in lowest grades Red is to Blue as 100 is to 110 and for highest grade subgroup it is 100 to 404; that is Red lost 73 per cent., almost three fourths of its 'pull' here. An examination of the graphic representation of the scales will make plain these and similar relations. In

addition the scales indicate that as we go along up the educational scales, taking both tables and graphic representations as guides, the whites lose somewhat their appreciation of all colors but Blue, which seems to be very highly valued, being more so with the highly educated, but the full-blood Indians appear to experience no such 'repression' of color preference, on account of education (4).

The Question of Background

In the treatment of the data we have had nothing to say of the effect of background which of course has played its part and whatever has been said of a color's preference is to be taken of that color as on a White background. When we have said 'Red' we might have said 'Red-on-White,' etc. To have given the experiment with colors having no background would have been impractical as a field enterprise.

In justification of the use of the White background we note that Indians use much of it in decorative work, as in feather designs, bead-work, blankets, pottery, etc. These show Red, Green, Brown, Black, etc., on White. But we rarely see the White with absolutely no colorative design. The writer recalls an almost white Navajo blanket with a very few small red and black squares to rejoice the eye. Another blanket was immaculately white to begin with, but on this a representation of an Indian ceremonial of more or less sacred significance was decorated with a procession of human (Indian) figures garbed in bright red and green uniforms, and the whole was set off by a few other colors much less conspicuous. While for the Indians White may be esteemed as a background, the experimental results show that just blank background is not what the Indian, or the white individual, desires.

Summary

1. There is for full-blood Indians a rather definite sequence of color preference for all the seven colors used in this experiment excepting Yellow and White, in which cases the preference for the former over the latter is not very conclusive. There is likewise a definite tendency for a preference sequence

of these seven colors for the whites, but the tendencies as determined for both races, by overlapping and scale positions are not so strong for them as for the full bloods. For the mixed bloods the sequence is even less secure as indicated by overlapping. For the three racial groups the sequences of the color preferences are:

	Rank						
	1	2	3	4	5	6	7
Full Bloods	Red	Blue	Violet	Green	Orange	Yellow	White
Mixed Bloods	Blue	Red	Violet	White	Green	Orange	Yellow
Whites	Blue	Green	Red	Violet	Orange	Yellow	White

From a statistical standpoint, as well as from the standpoint of judgment scales, the data indicates race differences in color preference, between full bloods and whites, and, by the test of overlapping, between the full bloods and the mixed bloods, but the differences are not so great for them as thus indicated.

2. Since the sequences of the colors are almost identical in all Indian educational subgroups, it may be said that this factor, education, has very little influence over the color preference with the Indian. In consequence we may say that for them their preference tendencies, on the whole, are stubbornly native.

3. Full-blood Indians are aware of more decided preferences, in general, than are the whites, in judging colors, if we abide by the objective results, disregarding the two exceptions, *i.e.*, the latter's high esteem for Blue and clear-cut discrimination between White and Yellow.

4. Among the Indians there are no outstanding differences between the sexes to the extent of altering the race differences. What slight tendencies there are for differences in this respect may be accounted for by the immediate influence of education.

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A SIMPLE VOICE KEY

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I

The importance of the language mechanism to human behavior gives a special significance to means of reducing it to quantitative terms. Of particular interest are its time relations, as denoting the time relations of more or less complicated mental processes. Graphic methods of studying these functions leave little to be desired from the standpoint of precision. The technique is so elaborate that their application is limited on practical grounds. The more frequent endeavor in psychology has been to get some function of the beginning speech process to operate an electric circuit. Such devices are known generally as 'voice keys.'

The movement that is most generally characteristic of a beginning speech response is an operation of the diaphragm and neighboring muscles, increasing the pressure of the air in the lungs. This will give an easily readable change in the pneumograph curve, but so far as the writers know it has not been used to operate an electric circuit. It is open to the objection that this movement may occur in anticipation, before the mental process it is desired to measure. Such a premature reaction would be difficult to recognize and control.

Another important factor in speech reaction is the opening of the lips. This does not characterize the so-called 'labials' as *f* (labiodental), *b* and *m*, which are formed with the lips closed. It is, however, sufficiently characteristic to have given rise to a special instrument, the lip key. Two arms are held together by the lips, on opening the lips a spring separates the arms, and operates an electric contact. This instrument has a disadvantage already mentioned in connection with the pneumograph. Cattell long since observed that the lips might be opened before the word was 'propositionized.' Hygienic and æsthetic objections are not impossible.

A third factor in speech reaction is the expulsion of breath. This takes place initially in all words save those that begin with 'explosives' (*e.g.*, *p*, *t*, *d*). If the expulsion of air is sufficiently strong, it may be utilized to operate an electric circuit. Its force varies greatly in different phases of speech. It is greatest upon the release of the so-called 'voiceless explosives' (*e.g.*, *p*, *t*, *k*). It is less effective with the voiced explosives (*e.g.*, *b*, *d*). It is comparatively ineffective during the enunciation of other consonants, (*e.g.*, *f*, *l*, *m*). Upon the release of such consonants, however, there may be a more or less effective puff of air by which a sufficiently delicate device of the Cattell or Dodge type is operable. Contact of the subject with the device is apt to be necessary.

A fourth factor in speech is the vibration of the vocal cords. This is present in the vowels, and in the so-called 'voiced' sounds (*e.g.*, *d*, *v*, *m*). It is absent in the 'voiceless' sounds of normal speech, *e.g.*, *t*, *f*, *s*, as it is in whispering. Sensitive devices of the Cattell or Dodge type are able to respond also to the vocal cords, but are probably more effectively operated by the breath stream. A device utilizing the laryngeal vibrations is that introduced by Römer and improved by Dunlap. Aside from sensibility an outstanding advantage of the Dunlap key is that the face is not touched or apparently confined in any way. The subject merely speaks against a metal disk. Dunlap's is the most highly specialized instrument for voice reactions that has been offered. Voice keys of the third and fourth classes are less subject to error through premature reaction than those of the first two. Premature vocalization or release of breath strong enough to operate the voice key is less likely to be undetected.

With regard to these and similar devices, it is appropriate to keep in mind the coördination between the subjective process it is desired to measure and the physiological process through which it has to be approached. Keys of the Cattell type are not readily operated until a free breath stream issues. Keys of the Dunlap type are not readily operated except by free vocalization or a forcible breath. The time between this

event and the beginning of the actual speech reaction is included in the measure obtained. The relation between higher mental processes and their linguistic expressions is not always as clear cut as between corresponding mental processes and the operation of telegraph keys. In ordinary usage, the voice key measures a single phase of a particularly complicated motor response. Its use is justified in that only through language and not telegraph keys are specially complicated mental processes workably expressed.

II

The John Hugo Manufacturing Company of New Haven, Conn., market a toy called the 'Radio Rex,' retailing at $2.00. It is made to represent a kennel, containing a little dog. The back of the kennel mounts a small dry cell and an electromagnet, with a pivoted armature, the magnet pulling against a spring. When the dog is pushed back into the kennel the armature is pressed against the electromagnet. When the armature touches the core of the electromagnet, the circuit through the magnet is completed, and the armature is held back, with the stretched spring pulling against it. With the breaking of the circuit, the armature, which is a long lever, kicks forward, causing the dog, in effect, to leap out of the kennel.

The device for breaking the circuit is as follows: on one side of the kennel a small triangular metal plate is suspended from a simple knife edge. In normal position this plate makes contact along its bottom edge from one copper wire to another. These parts are a portion of the circuit operating the electromagnet. A slight disturbance of the suspended plate breaks the circuit between the wires, and releases the armature. The intended source of such disturbance is calling at the apparatus in a fairly loud voice. If, for example, the name assigned to the dog, 'Rex,' be called, the dog can be made to appear.

It is plain that such a device is readily adaptable as a voice key as well as to any other purpose where a circuit is to be operated by a slight mechanical shock. One may

arrange a secondary circuit through the armature, which will be broken when the armature is released. In the present instance, this was accomplished by mounting a small copper brush on the base holding the magnet and accessories. When the armature touched the magnet, it also made contact through the brush, which was held against the armature by its natural resilience. With the release of the armature, it was drawn away from the brush by its spiral spring. Incidentally, the brush was dispensed with and both circuits operated between the magnet core and armature. Under these conditions the small dry cell was also eliminated and the entire apparatus operated by the laboratory current. Latency under these latter conditions averaged about 7 sigma, m.v. about 1.5 sigma.

The suspended plate and accessories, the voice key proper, were remounted upon a wooden arm some two feet long which, attached to a standard, could be brought into any convenient position with reference to the subject. A sort of wooden funnel was put around the key to assemble the sound waves but it is not an important accessory. What is gained in this way is probably lost through keeping the subject further away from the apparatus. As with the Dunlap key, the subject touches no portion of it.

Sensibility is conveniently varied by tilting the key and varying the weight with which the plate rests against the copper wires. It can be made more sensitive than is convenient to use, as it trips the armature at odd times, such as the fall of an exposure screen. In ordinary use its standard rests upon the floor of the building, from which it is separated by some cotton wadding. At ordinary working sensibility, a vigorous handclap seven inches from the plate tripped the release eleven times out of twelve. A loud shout nine feet away from the apparatus tripped the release three times out of four. A one gram weight dropped from a height of 4 cm. on a point of the wooden arm 19 cm. distant from the key tripped the release fifteen times out of twenty.

Under experimental conditions the conversational tone of voice cannot be relied on to operate the key. The best

operation is secured by instructing the subject to 'call' the response into the device. Some preliminary trials to determine a suitable loudness are desirable. A tone such as one might use talking to a person a hundred feet away is generally suitable. These considerations are sufficient to limit its applicability to controlled association responses. The key operates much more positively with men's voices than with women's.

The key is operable by either voice or breath, but the effective factor, in ordinary experimentation, seems to be the voice. It is risky to use a voice key without some knowledge of how it may be affected by the quality and intensity of the sounds spoken into it. In this connection the following observations are offered:

A series of seven three-letter words was selected, beginning with as many typical sounds, namely *egg* (beginning with a vowel), *gun* (voiced explosive), *hit* (aspirate), *man* (nasal), *peg* (voiceless explosive), *set* (voiceless spirant), *the* (voiced spirant). Experiments were made as follows: first one of the words was exposed, the subject being requested to read it. Then the same word was exposed, the subject being requested to have his organs of articulation all set therefor and to call the word as a *simple reaction* at the first intimation of the fall of the screen. Then the same stimulus was given, the subject making a simple hand reaction with a telegraph key at the first intimation of the exposure. The seven words were given in irregular order until the cycle of observations had been completed five times. Eleven records of such experiments are available, three with one subject. There are thus 55 reading reactions for each word, 55 simple reactions with each word, and 385 simple hand reactions, 1,155 observations in all.

The reading times, and the simple vocal reaction times, are presented in terms of their *excess* over the simple hand reaction. All time units are sigma. All reactions were measured by a ballistic galvanometer of about 50 seconds double swing period, operating as a chronoscope. Measured instrumental latencies are deducted from the readings quoted.

The average hand reaction time in these experiments is 144, m.v. 21. The average excess over this of a simple vocal reaction time is 117 sigma. The average excess for each of the seven words ranges from 112 to 117.2 with all words but *set*, whose excess averages 144. There was obtained for each subject the mean variation of his five simple reactions with each word. The average of these quantities is 34. The average m.v. of the simple hand reactions is 21. It will be remembered that the absolute length of the simple hand reactions is a little more than half that of the simple voice reactions. It would seem that, in general, no special attention need be paid to the initial sound of a word, with voice keys of this type. As represented by the initial of *set* the voiceless spirant gives a somewhat increased time. It is well known that such sounds are ineffective over the telephone. Compound consonants, as in the word *string* for example, would be likely to still further delay the action of the key.

Tendency of the key to trip more promptly when the reaction is in a loud voice involves a source of greater error. Ordinary experience finds the apparatus delaying to break when the response is spoken comparatively low. Two subjects fairly shouted into the apparatus, and their simple voice reactions are much the shortest; but 28 and 37 sigma larger than their respective hand reactions. Their reading reactions also show the least excess. It was impracticable to standardize vocal intensities, but the following observations bear upon the point.

The words 'yes' and 'no' were used as reactions to a sound stimulus. Twenty reactions with each were made in a tone only sufficient to trip the release, and twenty shouted. The comparison is as follows:

Subject A						*Subject B*					
Yes			No			Yes			No		
	Av.	M.v.		Av.	M.v.		Av.	M.v.		Av.	M.v.
Loud....	161	19	Loud.....	165	14	Loud.....	202	22	Loud....	192	16
Soft.....	258	41	Soft.....	249	26	Soft.....	268	26	Soft.....	270	36

Some of this difference might be due to more concentrated attention in the case of the 'loud' responses. In the 'soft' responses some attention seems directed to regulating the intensity of the speech sounds. Observations were made through tripping the release by striking a telegraph key adjacent to the voice key. Twenty trials were made with a light blow just sufficient to ensure breaking of the contact. Average and m.v. of these were 29 and 1.5 sigma respectively. Ten trials were made with a smart blow, as hard as could conveniently be struck. Average and m.v. were respectively 27 and .9 sigma. In this case it would appear that the intensity of the mechanical disturbance does not materially affect the quickness of the break. Its quickness was tested with maximal shouts immediately before the apparatus, and at a distance of 6 ft. Ten observations each showed results as follows:

	Subject *A*		Subject *B*	
	Adjacent	6 ft.	Adjacent	6 ft.
Av.....	189	259	184	247
M.v.....	22	31	21	48

There is seen to be a marked difference in favor of the greater commotion of the voice key by the closer shout. Some of the difference might be due to lessened intensity of the stimulus at the greater distance. Hand reactions were taken, indicating that this factor was relatively ineffective in the following results:

	A		*B*	
	Av.	M.v.	Av.	M.v.
Near.....	117	13	131	14
Far.....	123	14	114	08

It would appear that differences of the order of 70 sigma are producible by variations in the intensity of the vocal reactions. Single shocks do not show such difference according to their

strength, and the appearance is that a feeble commotion, when continued, 'summates' to an effect sufficient to break the contact. In ordinary use, unaccented portions of polysyllables may hardly be expected to operate the key.

If one recalls the phonetic conditions governing voice keys, one can get some idea of how absolute excess time in simple vocal over hand reactions may be used up. In the case of an initial vowel, the diaphragm must get up sufficient air pressure to operate the vocal cords. For a voiceless explosive (such as *p*) pressure should be already present behind the occlusion but the lips will give slightly before parting. In the case of explosive sounds the length of the neural arcs is more favorable to voice than to hand reactions. In the *p* sound of English there is also a slight unvoiced interval after the explosive before the cords operate, which would further delay the key unless it were operated by the puff of air. Other consonants are similarly ineffective until released, and in the case of voiceless spirants or compound consonants this effect is maximal.

Data are not available to the writers to indicate how these properties in the more specialized voice keys compare with the present simple one. The sensitiveness claimed for the former is not claimed for the Rex. In general serviceability the Rex's simplicity, ease of manipulation and economy make it more nearly equal.

There may be mentioned a few observations made with a breath key, so arranged with a tambour that a slight increase of pressure broke an electric circuit. To get this pressure under the condition of speech, it was necessary to confine the breath stream with a mouth-piece, nor was satisfactory operation obtained except with initial voiceless explosives. On the other hand, both reading and simple vocal times were very much shorter with this device. Vocal reactions with the breath key are of the order of hand reactions in shortness, and the reading reactions are from 100 to 200 sigma shorter than those observed with the 'Rex.' Comparison was made of initial *p* and *k* sounds with evidence that the latter provided the more prompt release. (The *p* sound is, however, more

positive in breaking the circuit.) In general, it seems that a key operated by the vocal cords, while especially convenient to manipulate, may include as much as 200 sigma of processes that are not strictly mental. A key operated by breath times the mental process more closely under favorable conditions, but for considerations already named, its use is restricted.

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RESULTS OF VARIATIONS IN LENGTH OF MEMORIZED MATERIAL

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I. Problems, Methods, and Subjects

In planning the present experiment we were primarily interested in discovering what type of relationship exists between the length of memorized material and its susceptibility to retroactive inhibition. Our data, however, also bear very directly upon three other fundamental problems of memory: The nature of the relationships (1) between the length of material and the form of the curve of memorizing; (2) between the length of material and the difficulty[1] of memorizing it; and (3) between the length of material and the amount of it retained after a certain interval. These other problems will be discussed first when we come to consider our results.

Ten subjects served in this experiment. They were graduate and advanced undergraduate students in experimental psychology.

The materials employed were lists of nonsense syllables. Each list contained 6, 9, 12, 15, or 18 syllables. The syllables were exposed by means of a hand-operated memory drum which has been a standard instrument in the Chicago laboratory for several years. The time for the single exposure of a syllable was 2 seconds. The experimenter was made aware of these intervals by means of a mercury cup metronome in

[1] Difficulty being measured in terms of repetitions or time required for complete mastery.

circuit with a head-phone. The metronome was not, of course, in the experiment room.

The *anticipation*[1] method was employed. The entire list was presented once and, after that, the subject, upon being presented with a given syllable, attempted to pronounce the three letters of the next syllable in the list before that syllable appeared. He was not permitted to anticipate aloud more of the list than that syllable following the one which was exposed. Luh made use of the method of having the letters of a syllable, rather than the syllable itself, pronounced, and it is obviously a safeguard against errors of enunciation being mistaken by the experimenter for errors of memory. Each list was presented until the subject had successfully anticipated during a single presentation all but the first of its syllables. The first syllable served merely as a cue. In the learning of a list, then, it may be considered that one less association was formed than there were syllables in that list. The number of presentations necessary for complete learning was taken to be one less than the number of presentations of the list. The correct presentation was a test rather than a practice trial.

We were interested in the retention of the lists as well as in the manner in which they are learned, *i.e.*, the amount of the material recalled at different stages in the memorizing process. This retention was measured in terms of a *recall* score and a *saving* score. Both types of score were obtained for each list learned.

The *recall* score is the percentage of a memorized list recalled when that list is given a first re-presentation some time after the completion of those presentations required for the initial learning of the list. This score can be expressed as follows:

$$\text{Recall Score} = \frac{\text{Number of syllables correctly anticipated during first re-presentation of list}}{\text{Number of syllables in list} - 1^{2}} \times 100$$

[1] Used by Finkenbinder, E. O., 'The Curve of Forgetting,' *Amer. J. of Psychol.*, 1913, 24: 8–32, and by Luh, C. W., 'The Conditions of Retention,' *Psychol. Monog.*, 1921, 30.

[2] The first syllable which, as we have noted, was merely a cue.

The *saving* score expresses the relationship between the number of presentations required to learn a given list and the number of presentations required to relearn the list some time after the completion of the first learning. In detail this relationship can be expressed as follows:

$$\text{Saving Score} = 100 - \left[\frac{\text{Number of presentations required for relearning}}{\text{Number of presentations required for original learning}} \times 100 \right]$$

The subjects were requested to refrain from devising or utilizing any mnemonic schemes to aid them in memorizing.

Before the experiment proper, each subject learned one list of 12 syllables a day for a period of six days, and then relearned the same list after an interval of 15 minutes. This was done to decrease the effect of practice during the experiment. The results of our work indicate, however, that the subjects were still improving in their ability to memorize this kind of material until the end of the experiment. This was to be expected and we guarded against this disturbing effect by arranging the order in which the different subjects went through the different conditions of the experiment in such a way that these conditions were affected by approximately equal amounts of practice. There were ten experimental conditions and ten subjects, and each subject went through these conditions in a different order. This device did not exhaust the number of possible orders, but it insured each condition being first, second, and so on an equal number of times in the series of conditions.

Table I. displays the plan of our experiment.

It can be seen that the results of such an experiment would give data bearing upon the retroactive effects of a constant activity—the memorizing of a list of 12 syllables—upon previously memorized lists of varying length. The normal or rest interpolation was, of course, rest in only a relative sense. It was from this same experimental situation that our data on length and the memory curve, length and difficulty, and length and retention were obtained.

Our experiment contained three cycles. That is, each of our subjects was tested three times under each experimental condition. This gave us a total of 30 values apiece for each

TABLE I

O = Original memorizing of a list of nonsense syllables, 6, 9, 12, 15, and 18 designating the number of syllables in the list.

I = Memorizing of a list of nonsense syllables immediately following the memorizing of a first or original series, and 12 designates the length of this interpolated list, *i.e.*, 12 syllables.

Rest = Casual reading of the daily paper with no attempt to memorize its contents. During this period the subjects refrained from rehearsing O or I.

RO = Relearning of original list of syllables. The interval between the completion of O and the beginning of RO was always 20 minutes. In the case of the practice series, it was 15 minutes, but this was not long enough to make sure that all subjects would complete I.

Condition		Interpolated Period of 20 Minutes	
I	O 6	I 12, Rest	RO
II	O 6	Rest	RO
III	O 9	I 12, Rest	RO
IV	O 9	Rest	RO
V	O 12	I 12, Rest	RO
VI	O 12	Rest	RO
VII	O 15	I 12, Rest	RO
VIII	O 15	Rest	RO
IX	O 18	I 12, Rest	RO
X	O 18	Rest	RO

of these conditions. This would hardly have given statistical accuracy except for the fact that our conditions were arranged in a definite progressive series so that the consistency as well as the absolute magnitudes of differences could be considered in drawing conclusions. In the case of a number of issues we were able to include 60 values under each condition. For instance, in considering the *difficulty* of lists of different lengths, we could include under a single condition the original lists of 6 syllables learned either before rest or before learning an interpolated list.

In no case was a subject tested under more than one condition on a single day. In most cases four tests were made during a week.

II. Length of Material and the Memory Curve

When material is learned by the anticipation method, a record is secured, for each presentation, of the amount that can be recalled (anticipated) up to that point. We have 60 sets of such records for the memorizing of each length of list employed in our experiment. From these data we have plotted the memory curves for the various lengths of material.

In Fig. 1 we have plotted the absolute number of syllables recalled or anticipated against the absolute learning time. The unit for the latter is one presentation of one syllable. Using this unit, one presentation of a 12-syllable list requires as much absolute learning time as, for instance, two presentations of a 6-syllable list, or as two thirds of a presentation of an 18-syllable list. This is as it should be if we are interested in returns for absolute amounts of time.[1] The curves of the figure represent the averages for all subjects and all cycles. Each value on each curve is an average of 60 individual measurements.

Whatever examination is made of such matters as the correlation between *relative* amounts learned and *relative* amounts of learning time, this correlation between absolute amounts learned and absolute amounts of learning time should receive primary consideration. Because of the simpler character of the variables involved, this latter correlation should possess more fundamental importance.[2]

The rate of learning all lengths of the material decreases with successive presentations. The curves show a highly regular variation from that of the shortest list to that of the longest. The shorter the list the more associations are formed per absolute unit of time very early in the learning process, and the fewer are the associations that are formed later. The rates at which associations are formed in the shorter materials are exceeded by the rates at which associations are formed in the longer materials only as the rate

[1] Professor L. L. Thurstone, of the Carnegie Institute of Technology, suggested this convenient method of measuring learning time in terms of syllables presented.

[2] Kjerstad seems to have overlooked this fact. He considers only the former type of correlations. See Kjerstad, C. L., 'The Form of the Learning Curve for Memory,' *Psychol. Monog.*, 1919, 26.

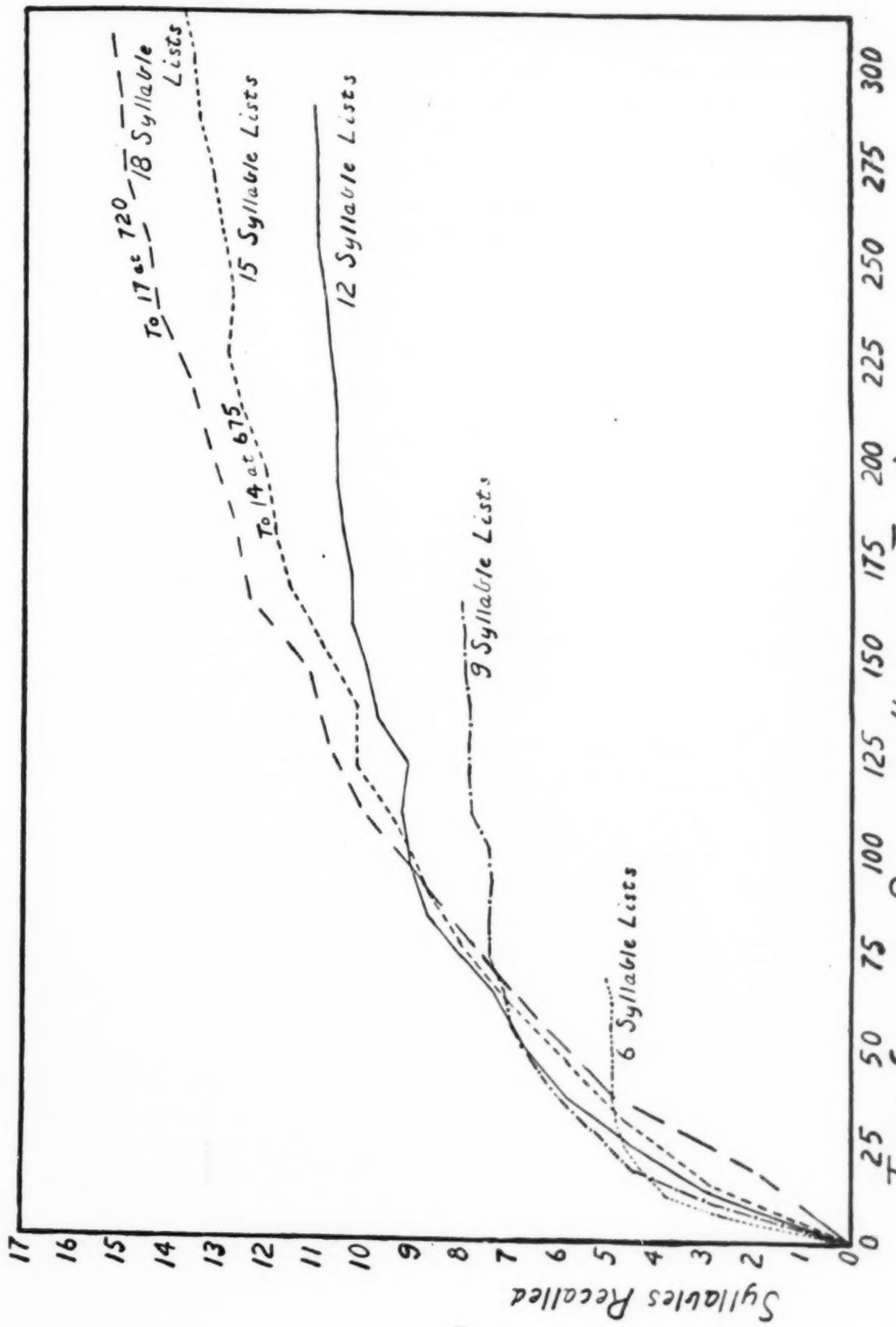
To 17 at 720
18 Syllable Lists
15 Syllable Lists
To 14 at 675
12 Syllable Lists
9 Syllable Lists
6 Syllable Lists
Total Syllables Presented (Learning Time)
Syllables Recalled
0 25 50 75 100 125 150 175 200 225 250 275 300
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

FIG. 1

of learning the shorter materials decreases with the approach of complete learning. The fact that the absolute rate of learning longer materials eventually exceeds that of shorter materials has an obvious explanation in the fact that the limit of possible associations in the case of the shorter materials is reached first. But the initially more rapid rate of learning for the shorter materials has no such obvious explanation. Why should two presentations (12 units of learning time) of a *6-syllable* list result in the formation of a greater number of associations than one presentation (also 12 units of learning time) of a *12-syllable* list?

A possible explanation of the fact before us is as follows: How much will be learned in a given period of time is affected in two almost contradictory ways by the length of the material before us. If there is a very small amount of material before us we can naturally learn only a small amount in a given period of time. In order to learn the maximum amount, then, in the time at our disposal, it is necessary to have at least as much material to work upon as is possible for us to learn. Probably we can profitably work with a larger amount of material than we can learn. There may be, as has been suggested, a tendency to learn easier things first. In that case we should, for maximum results, have enough material before us to give us some range of choice as to what is to be learned. (This choice need not be explicit.) But it is probable also that we may have too much material before us for best results. In that case we may suffer, not because of an exhaustion of the possibilities for association, but because there are so many possibilities that some of these interfere with those associations which might easily be fixated under ordinary conditions. Although this seems to us the most feasible explanation of the slower rate of learning for the longer lists, it is not the only one. Consider the fact that two presentations of a 6-syllable list give greater returns than one presentation of a 12-syllable list. Factors which might be effective here are the difference in study time per syllable under the two conditions, and other differences in the methods of study; *e.g.*, an element of repetition enters into two

presentations of 6 syllables which does not enter into one presentation of 12 syllables.

Turning to the interpretation of our curves, we may suppose that with all of our lists there was, during the early period of the learning, more than the minimum amount of material necessary for getting the maximum results out of that early period. It is also likely that the longer the lists the more possibilities they offered for interfering associations. After the earliest portion of the learning time, however, the exhaustion of the possibilities of the shorter list more than compensates for the possibilities for interferences within the longer lists, and the absolute rates of learning become more rapid for the longer materials.

We might summarize the curves of Fig. 1 by saying that, within the limits of our experiment, the shorter the material the greater the rate of learning, until the possibilities for forming associations become considerably exhausted. As we have pointed out, there may be lists shorter than our 6-syllable lists which would give a relatively slow initial rate of learning, but we did not have such lists in our experiment.

Up to this time we have been considering absolute amounts learned in absolute amounts of learning time. The curves of Fig. 1, because they approach different absolute limits at different absolute rates, are difficult to compare in a relative way. For this reason we have approximated Kjerstad's method[1] of dividing into the same number of parts the different lengths of time spent in learning the lists of different lengths and also of dividing into the same number of parts the total amounts learned in the case of the lists of different lengths. Kjerstad divided the time of learning into sixths and the amount learned into per cents. We have divided both time of learning and amount learned into per cents. The results are shown in tabular form (Table II.) instead of in a set of curves for the reason that the five curves happen to be almost coincident. In order to obtain these values, however, we plotted in percentile form curves representing the relationship between certain fractions of the total learning time and

[1] *Op. cit.*, pp. 25–27.

certain fractions of the amount learned. The values shown in Table II. were read off from these curves.

TABLE II

PERCENTAGES OF LISTS OF DIFFERENT LENGTHS LEARNED IN DIFFERENT PERCENTAGES OF THE TOTAL TIME SPENT LEARNING THOSE LISTS

Percentages of Total Learning Time	Length of List				
	6 Syllables	9 Syllables	12 Syllables	15 Syllables	18 Syllables
5	30	34	30	32	28
10	52	51	46	52	44
25	81	76	72	80	74
50	97	93	88	99	95
75	98	97	96	99+	98
100	100	100	100	100	100

These percentile figures (Table II.) confirm a contention made by Kjerstad and borne out by his results that the form of the memory curve is independent of the length of the material memorized. Remarkably similar proportions of the material to be learned are learned in similar relative stages in the learning processes. What differences occur seem to be unrelated, at least in any continuous fashion, to the matter of length.

III. LENGTH AND DIFFICULTY

The relationship between the length of material and the number of repetitions required to memorize it has had considerable attention. The main body of evidence from experiments conducted by Ebbinghaus,[1] Meumann,[2] Henmon,[3] Lyon,[4] and Kjerstad,[5] indicate that longer materials require more repetitions for memorizing than do shorter materials. But there is considerable disagreement as to the rate at which repetitions must be added with additions to the length of the material. According to Ebbinghaus, Meumann, and Lyon,

[1] Ebbinghaus, H., 'Memory,' 1885, tr. by Ruger and Bussenius, 1913.

[2] Meumann, E., 'The Psychology of Learning,' 1912, tr. by Baird.

[3] Henmon, V. A. C., 'The Relation Between Learning and Retention and Amount to be Learned,' J. EXPER. PSYCHOL., 1917, 2, 476–484.

[4] Lyon, D. O., 'Memory and the Learning Process,' 1917.

[5] Kjerstad, *op. cit.*

early increases in length are accompanied by more marked increases in repetitions than are later increases in length. Henmon and Kjerstad did not obtain this result, due, perhaps, to the fact that the shortest lists used by them contained from 10 to 12 syllables, while the rapid increase in repetitions referred to occurred between lists of 8 syllables and those of 12 syllables.[1] This initial rise in the number of repetitions is usually such that there is an increase not only in *repetitions*, but also in *repetitions per syllable*. With further increases in the length of the material there continue to be increases in *repetitions*, but not necessarily in *repetitions per syllable*.

Our results on this point are given in Table III.

TABLE III

AVERAGE NUMBER OF REPETITIONS PER SYLLABLE OF LISTS OF DIFFERENT LENGTH. N FOR EACH VALUE = 20, EXCEPT FOR THE AVERAGES OF THREE CYCLES WHERE $N = 60$

Length of List	6 Syllables	9 Syllables	12 Syllables	15 Syllables	18 Syllables
Cycle I	0.67	0.90	1.11	1.20	1.21
Cycle II	0.62	0.82	0.85	0.98	0.99
Cycle III	0.45	0.77	0.79	0.80	0.73
Averages for Three Cycles	0.58	0.83	0.92	0.99	0.98

Two out of three cycles of this experiment agree in showing an increasing number of repetitions per syllable with increasing length. In all cycles there is a marked increase in repetitions per syllable as the length is increased from 6 to 9 elements. In all cycles, this increase grows less as the length is further increased. In one cycle, the third, there is an actual decrease in repetitions per syllable as the longest length is reached. These findings agree with the majority of those obtained with nonsense syllables in showing a sudden increase in the number of repetitions per syllable with the early increases in the length of the material, and a less pronounced increase in repetitions per syllable or, perhaps even a decrease, with later increases in the length of the material. Our data point more positively toward a continuous increase

[1] Kjerstad, *op. cit.*, p. 80, has given a table summarizing the findings of various investigators on the relation between length and repetitions.

in *repetitions per syllable* with increasing lengths of material than do those of other investigators. Whether or not this continuous increase is obtained may easily be a function of any one of a number of minor differences between the conditions of other experiments and our own. For instance, our results show this continuity only during the first two cycles which indicates that familiarity with this type of learning may have something to do with the matter. Weber and Knors are said to have obtained a continuous increase in repetitions per syllable only with wholly unpracticed observers.[1] While at no time during the actual experiment were our learners wholly unpracticed, the general direction of the two sets of results is the same.

The fact that later increases in the length of material do not always add to the required repetitions per syllable has at times been taken to mean that longer material can be memorized with relatively less effort than shorter material.[2] This would be true if *one repetition* stood for a constant amount of time or effort, but it does not. As a list of syllables becomes longer, each repetition requires that much more time or effort. If, then, one extra repetition is added for each added syllable, it means, since the added repetitions are longer and longer, that the effort required to master the material is increasing, not as its length, but faster than its length. It is undoubtedly difficult to think clearly of variations in effort in terms of such a variable unit as *one repetition*. Lyon and Kjerstad have both taken account of this fact and have shown the correlations between length and *time* taken to memorize. In considering these correlations in our own data and also in those of certain other investigators, we have again followed the procedure, described in our section on memory curves, of measuring *time* in terms of the total number of units of material presented.

In Fig. 2 we have plotted the relationships between length of material and units presented before learning is achieved for the data of Ebbinghaus, Meumann, and Henmon for

[1] See Meumann, *op. cit.*, p. 275.

[2] See Meumann, *op. cit.*, p. 274 ff., and Henmon, *op. cit.*

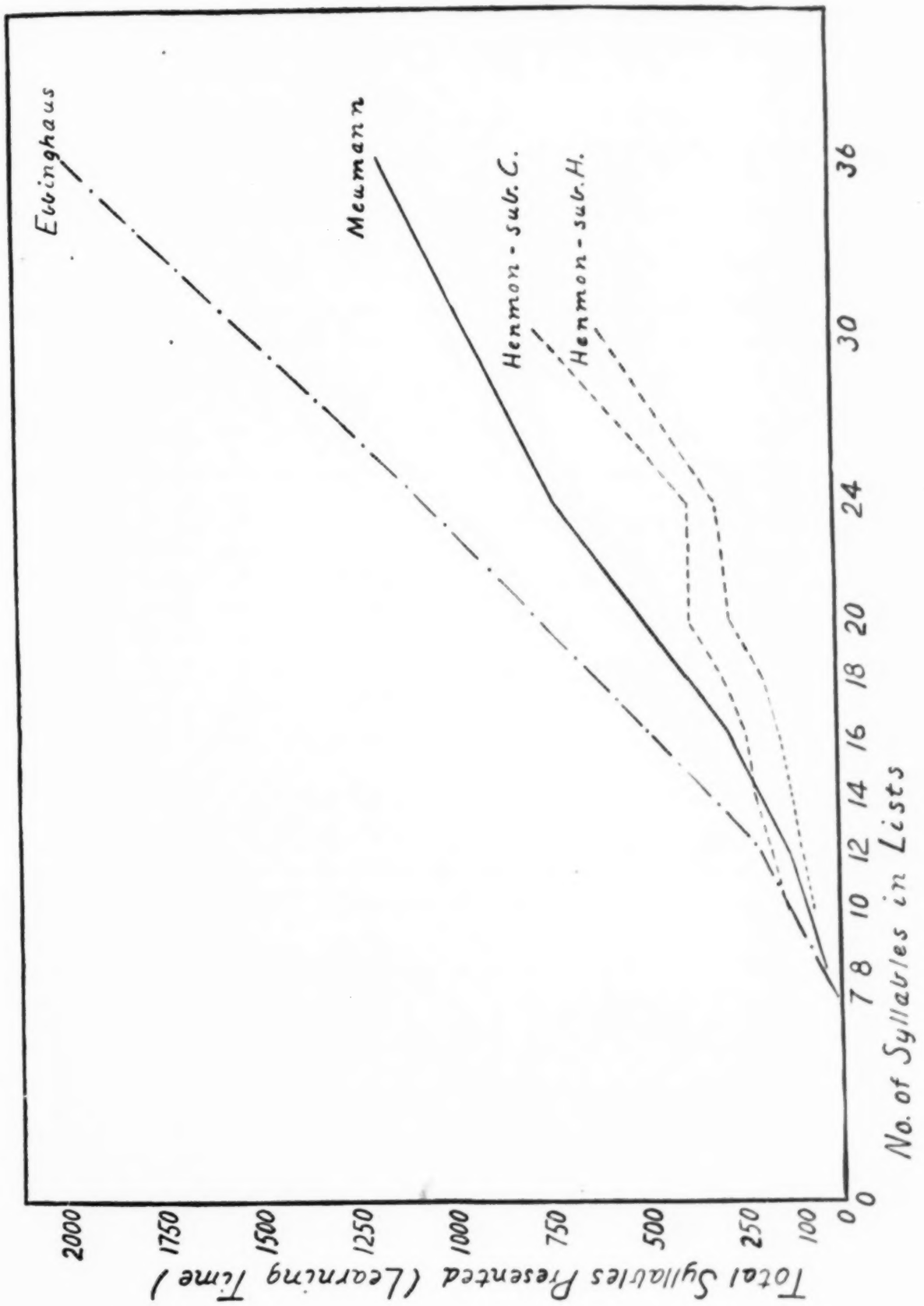
Ebbinghaus
Meumann
Henmon - sub. C.
Henmon - sub. H.
Total Syllables Presented (Learning Time)
2000
1750
1500
1250
1000
750
500
250
100
0
0
7 8 10 12 14 16 18 20 24 30 36
No. of Syllables in Lists

FIG. 2

nonsense syllables.[1] The two Henmon curves and that of Ebbinghaus show increasing amounts of time (total units presented) with increasing length, and this increase takes place at an increasing rate. The Meumann curve indicates a positive acceleration in the early portion of the time-length curve and a negative acceleration later. Lyon has plotted his data in similar fashion. For practically all of his material there are positively accelerated curves expressing the relationships between learning time and length. Binet and Henri[2] have also given such a relationship in the case of memory for numbers. In Table IV. we have presented the time-length relationships for Henmon's data on meaningful material.

Table IV

Av. of Three Subjects—1, 2, 3, 4, and 5 Stanzas of 'In Memoriam'

About 25 measures in toto for each condition.

Stanzas	Repetitions	Total Stanzas
1	3.5	3.5
2	6.3	12.6
3	8.6	25.8
4	10.0	40.0
5	12.2	61.0

One Practiced Subject—1, 2, 3, 4 Stanzas of 'Childe Harold'

Stanzas	Repetitions	Total Stanzas
1	8.3	8.3
2	9.3	18.6
3	10.0	30.0
4	9.1	36.4

Nine Unpracticed Subjects—'Childe Harold' (?)

Stanzas	Repetitions	Total Stanzas
1	4.6	4.6
2	9.7	19.4
3	11.8	35.4
4	15.9	63.6
5	15.3	76.5

One Subject—100-, 200-, or 300- Word Passage from Arnold and Huxley

Words	Repetitions		Total Words	
	Arnold	Huxley	Arnold	Huxley
100	5.5	7.4	550	740
200	6.7	7.9	1,340	1,580
300	6.7	7.4	2,010	2,220

[1] Such curves are roughly comparable as to general form even though we do not stop to inquire whether *one presentation of one syllable* means the same in terms of *time* from experimenter to experimenter.

[2] Quoted by Henmon.

(Henmon, himself, gives this relationship in terms of repetitions-length only.) The curve for "In Memoriam" would show a continuous positive acceleration, those for "Childe Harold" would be first positively and then negatively accelerated, and those for the prose material from Arnold and Huxley would have a slight negative acceleration.

Figure 3 shows the time-length relationship for our own data. The average curve and the curves for two out of three of the cycles are positively accelerated. The one for the last cycle is first positively and then very slightly negatively accelerated. It may be that this negative acceleration, appearing as it does in the last cycle, is in some way a product of familiarity with this type of material. There is general agreement among our own data and those of other investigators that the time-length relationship has an early positive acceleration. In some cases this is continuous to within the limits of the experiment, in some cases it is followed by linearity, and in some cases it is followed by a negative acceleration.

But the typical thing is the early positive acceleration, or increase in relative difficulty with increasing length. In no case has early negative acceleration, or decreasing relative difficulty, been demonstrated. This fact must be due, in part at least, to the particular lengths of material studied. But we should not expect any continuous negative acceleration, because that would ordinarily imply that after a certain point in length is reached, additional increases in length would not be accompanied by additional increases in difficulty. It seems a sensible expectation that in its later stages the time-length relationship will be linear or positively accelerated and that any negative accelerations which have appeared are temporary.

IV. Length and Amount Retained

There are not a great many results on the relationship between length of material and the rate at which it is forgotten. The evidence is probably somewhat in favor of slower forgetting for longer materials.[1]

[1] See Henmon, *op. cit.*, for a review of evidence on this point.

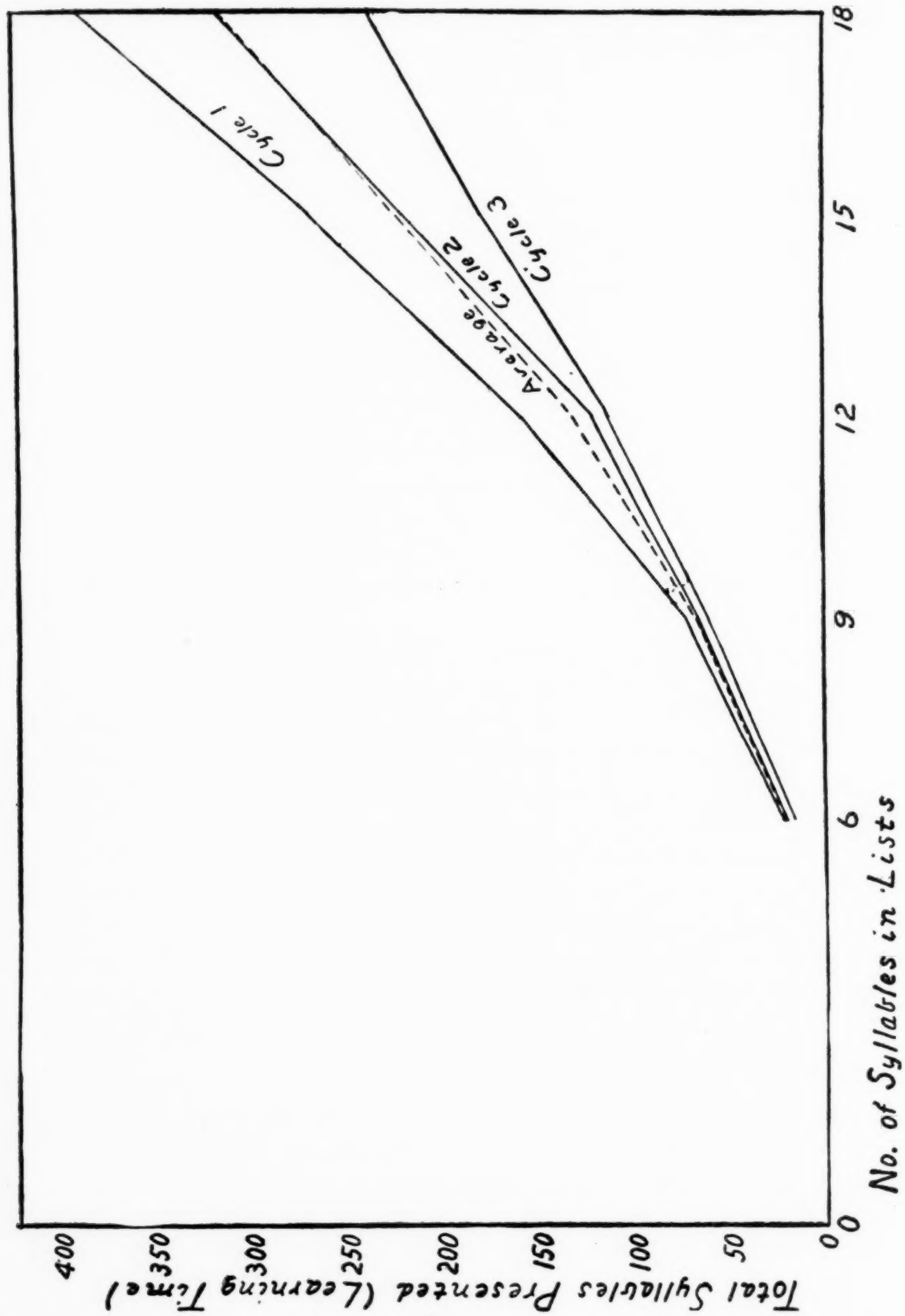
Cycle 1
Average
Cycle 2
Cycle 3
0
6
9
12
15
18
No. of Syllables in Lists
0
50
100
150
200
250
300
350
400
Total Syllables Presented (Learning Time)

FIG. 3

Table V. gives the relative amounts *recalled* and Table VI. the relative amounts *saved* of the lists of different length after a period of 20 minutes spent in newspaper reading. The values are averages of the performances of all of our subjects.

TABLE V

PER CENTS. *Recalled* AFTER 20 MINUTES

n = 10 for each value except averages where n = 30

Length of List	6 Syllables	9 Syllables	12 Syllables	15 Syllables	18 Syllables
Cycle 1	60.0	71.2	75.4	74.2	85.3
Cycle 2	70.0	78.7	79.0	76.2	79.4
Cycle 3	84.0	85.0	81.8	80.7	80.5
Average of 3 cycles	71.3	78.3	78.7	77.0	81.7

TABLE VI

PER CENTS. *Saved* AFTER 20 MINUTES

n = 10 for each value except averages where n = 30

Length of List	6 Syllables	9 Syllables	12 Syllables	15 Syllables	18 Syllables
Cycle 1	51.3	74.4	80.7	84.2	88.1
Cycle 2	71.4	78.5	71.5	80.8	88.6
Cycle 3	83.3	83.5	82.2	77.2	82.1
Average of 3 cycles	68.7	78.8	78.1	80.7	86.3

In general these results show a relatively more rapid forgetting, or poorer retention, for the shorter lists. It is only in Cycle 1, and according to the *saving* method, however, that this relationship is continuous. According to both methods of scoring, the relationship is if anything reversed by the third cycle. Apparently, practice in memorizing nonsense material may at least decrease the relative rate of forgetting shorter materials. This possibility should be further investigated.

V. LENGTH AND SUSCEPTIBILITY TO RETROACTIVE INHIBITION

The degree of retroactive inhibition has been found to vary with the similarity between the originally memorized material and the interpolated activity or *work*,[1] with the

[1] Robinson, E. S., 'Some Factors Determining the Degree of Retroactive Inhibition,' *Psychol. Monog.*, 1920, 28.

degree of learning,[1, 2] with the conditions of learning,[3] with the subjects employed,[4] and with certain other factors.[5] The present experiment affords data bearing on the relationship between the length of memorized material and its susceptibility to retroactive inhibition.

Table VII. shows the differences between the percentages

TABLE VII

DIFFERENCES BETWEEN PERCENTAGES OF DIFFERENT LISTS *Recalled* UNDER *Rest* AND *Work* CONDITIONS—ABSOLUTE INHIBITION

n = 10 for each value except averages, where n = 30

Length of Lists	6 Syllables	9 Syllables	12 Syllables	15 Syllables	18 Syllables
Cycle 1	8.0	33.7	30.0	26.4	29.5
Cycle 2	6.0	38.7	44.5	28.6	22.4
Cycle 3	36.0	46.3	36.4	32.2	15.3
Averages of 3 cycles	16.7	39.6	37.0	29.1	22.4

PERCENTAGES ABOVE DIFFERENCES ARE OF AMOUNTS *Recalled* UNDER *Rest* CONDITIONS—RELATIVE INHIBITION

n = 10 for each value except averages, where n = 30

Length of Lists	6 Syllables	9 Syllables	12 Syllables	15 Syllables	18 Syllables
Cycle 1	13.3	47.3	39.7	35.5	34.5
Cycle 2	8.5	49.1	56.3	37.5	28.2
Cycle 3	42.8	54.4	44.5	40.2	19.0
Averages of 3 cycles	21.5	50.3	46.8	37.7	27.2

of the original materials recalled after a *rest* (newspaper reading), during which the subjects abstained from rehearsing the original material, and after *work*, (after memorizing an interpolated list of 12 syllables). All of these differences are positive and indicate greater efficiency after interpolated *rest*. This table also shows the percentages which these differences are of the percentages of the lists of different length recalled

[1] Heine, R., 'Über Wiedererkennen und rüchwirkende Hemmung,' *Zsch. f. Psychol.*, 1914, 68, pp. 161–236.

[2] Robinson, *op. cit.*

[3] Tolman, E. C., 'Retroactive Inhibition as Affected by Conditions of Learning,' *Psychol. Monog.*, 1917–18, 25.

[4] Webb, L. W., 'Transfer of Training and Retroaction,' *Psychol. Monog.*, 1917, 24.

[5] Such as the method of measuring retention (see Heine, *op. cit.*)

after *rest*. In other words, we have here inhibition expressed in both absolute[1] and relative amounts. Table VIII. contains

TABLE VIII

DIFFERENCES BETWEEN PERCENTAGES OF DIFFERENT LISTS *Saved* UNDER *Rest* AND *Work* CONDITIONS—ABSOLUTE INHIBITION

n = 10 for each value except averages where n = 30

Length of Lists	6 Syllables	9 Syllables	12 Syllables	15 Syllables	18 Syllables
Cycle 1	3.6	16.4	15.6	14.8	12.0
Cycle 2	32.0	22.4	11.5	10.0	21.0
Cycle 3	40.0	25.9	23.7	16.7	15.2
Averages of 3 cycles	25.2	21.6	16.9	13.8	16.1

PERCENTAGES ABOVE CONDITIONS ARE OF AMOUNTS *Saved* UNDER *Rest* CONDITIONS—RELATIVE INHIBITION

n = 10 for each value except averages where n = 30

Length of Lists	6 Syllables	9 Syllables	12 Syllables	15 Syllables	18 Syllables
Cycle 1	7.0	22.0	29.3	17.6	13.6
Cycle 2	44.8	28.5	16.1	12.3	23.7
Cycle 3	48.0	31.0	28.8	21.6	18.5
Averages of 3 cycles	33.3	27.2	24.7	17.2	18.6

the same items as derived from the *saving* scores. Both tables are based upon the performances of our group as a whole.

Considering both tables, the most consistent tendency is in the direction of absolutely and relatively less inhibition with increasing length of the disintegrated material. The most marked exception to this generalization lies in the fact that in two out of three cycles according to *recall* and in one cycle out of three according to *saving* the least inhibition is present in the case of the shortest, *i.e.*, the 6-syllable, list. The other exceptions to the general tendency are not regular enough to be considered very seriously.

The general tendency toward decreasing susceptibility to retroactive inhibition with increasing length is one that

[1] Of course, the absolute amounts are themselves relative in the sense that they are percentages of the original materials.

might have been expected in light of the fact that the longer materials are forgotten more slowly or are, in other words, less susceptible to the disintegrating effects of agencies less inhibitory than the memorizing of an interpolated list of syllables. We found, however, that the more rapid forgetting of the shorter materials is probably a function of lack of practice in this type of memorizing. We might expect, then, that the greater susceptibility of the shorter lists to retroactive inhibition would also tend to disappear with practice, but it is at least as pronounced in the last cycle as in the first. It is also difficult in the light of our facts in regard to the rate at which the different materials were forgotten to explain why in certain cases the very shortest lists were least affected by retroaction.

With the facts at our disposal we can do little more than point out the general tendency toward decreasing susceptibility to inhibition with increasing length and the striking exception, rather too consistent to be accidental, supplied in certain cases by the material of shortest length. Evidently susceptibility to retroactive inhibition decreases with length only after a certain minimum length has been passed. It would be interesting to know whether this inverse relationship between susceptibility to retroactive inhibition and length has also an upper limit.

One theory in regard to retroactive inhibition explains this phenomenon as due to the transfer of elements of the original memorizing over to the situation of learning the interpolated list. This is, then, alleged to embarrass the recall of the original material.[1] If that is the case, we might expect to find the learning of the interpolated list favorably or unfavorably affected by the previous learning of an original list and we might also expect the amount of that effect to vary in some way with the amount of inhibition present for the lists of different length. We have therefore calculated the average number of repetitions required to memorize a 12-syllable interpolated list after learning 6-, 9-, 12-, 15-, and

[1] For discussions of the transfer theory or theories of retroactive inhibition see De Camp, J. E., 'A Study of Retroactive Inhibition,' *Psychol. Monog.*, 1915, 19; Webb, *op. cit.;* and Robinson, *op. cit.*

18-syllable original lists. These averages are 10.1, 10.5, 10.6, 9.9, and 11.4 respectively. The average number of repetitions required to memorize a 12-syllable list when not preceded by the learning of another list was 11.0. In four out of five cases, then, there is a slight positive transfer from the memorizing of the original list to the memorizing of the interpolated list. Furthermore, with the exception of one case, there is a continuous decrease in the amount of this transfer with increasing lengths of the first list, *i.e.*, with those conditions where inhibition was, in general, less marked. One should, however, hesitate to accept these facts as a confirmation of the transfer hypothesis. The amount of transfer demonstrated is in every case small and at least it does not seem sufficiently marked to furnish a cue for the complete explanation of the marked inhibition present under the conditions of this experiment.

VI. Summary of Results

1. The memory curves for all of the lengths of material studied show a general negative acceleration. These curves vary regularly according to the lengths of material represented. The shorter the material, the more rapidly do the earlier stages of its learning proceed and the earlier the stage of relatively slow progress is reached. In other words within the limits studied, the more unlearned material facing the subject, the fewer associations will be formed in the early portions of the total study time. Later, when the possibilities for new associations offered by the shorter material are beginning to give out, more associations per unit of time will be formed where the material is longer.

2. The amounts of any list learned after certain amounts of study may be considered as percentages of the total material in that list learned in certain percentages of the total time required to learn that list. Curves plotted on the basis of such a consideration of our data show a remarkably close coincidence. This finding confirms a similar one by Kjerstad.

3. The number of repetitions required for complete learning increases rapidly with early increases in the length of

material and more slowly with later ones. This is in accord with previous findings. Our results show, not only a continuous increase in repetitions with increasing length, but also a continuous increase in *repetitions* per syllable. This is not in agreement with previous results, which have indicated an early increase in *repetitions per syllable* followed by a decrease.

4. The procedure of considering the relationship between length of material and repetitions required to learn it is not very satisfactory for determining the relationship between length and difficulty, because the *repetition* is a unit of effort which, itself, varies with the length of the lists employed. We have shown the relationship between length and a constant unit of effort, *i.e.*, one presentation of one syllable, both for the data of previous experiments and for our own. The trend of these results indicates a general negative acceleration. That is, as material becomes longer, it becomes relatively more difficult. Meumann's results furnish an exception and, according to Henmon, this relationship is not continuous. Logically, however, it is what we might expect.

5. Our findings agree with most earlier ones in indicating that shorter materials are more rapidly forgotten than longer materials. Familiarity with the experimental situation for some undetermined reason seems to remove this effect.

6. In general, there is a decreasing susceptibility to retroactive inhibition with increasing length. That there may be a lower limit to this law is indicated by the fact that in a number of instances the shortest lists employed were least affected by retroactive inhibition.

7. Twelve-syllable lists, learned immediately after other lists, are learned slightly more quickly than those learned without a previous list. This positive transfer is most marked where the first lists are shorter. But the effect is not great enough to be considered seriously as a demonstration of the place of positive transfer in retroactive inhibition.

DISCUSSION

THE STIMULUS ERROR, A REPLY

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Professor Weiss[1] objects to a conclusion to an experimental study of mine to the effect that "this experiment seems to show the futility of properly interpreting the statistical results of a purely behavioristic study without the control of the introspective report." [2] The study in question was the determination of the difference limen to lifted weights under the three different instructions to judge: (1) the weights (stimulus error); (2) pressure sensations and (3) kinæsthetic sensations in the wrist. Statistically these different instructions gave relatively different values for the difference thresholds.

It is claimed that these experiments are not purely behavioristic because no attempt was made 'to establish laws according to which weight discriminations are made by some social or anthropological unit.' It is unfortunate, perhaps, but in an experiment of this sort one seems to be limited to the use of the graduate student and the recent Ph.D. as one's 'anthropological unit' and, frankly, I find them more interesting as a unit than '. . . post-office clerks, store-keepers, housewives, etc.,' and much more readily obtainable about a psychological laboratory. It has always seemed to me that one, in reading an experimental paper, considered the experimental setting,—Watson (to whom one usually turns in considering Behaviorism) insists upon it.[3] Our 'stimulus error' setting is as exact as we could devise from the method suggested and implied by Watson (pp. 37) when he speaks of "asking the subject as we do in the verbal report method: *Is this light brighter or dimmer than another light*, or, *Is this tone lower or higher than that tone?*" (italics Watson's) and in his further discussion of the stimulus and difference thresholds (p. 52).

[1] Weiss, A. P., 'The Stimulus Error,' J. of Exper. Psychol., 1922, 5, 223–226.

[2] Fernberger, S. W., 'An Experimental Study of the "Stimulus Error,"' J. of Exper. Psychol., 1921, 4, 63–76.

[3] Watson, J. B., 'Psychology,' 1919, p. 28.

Unfortunately we have found elsewhere that different individuals react differently under such instructions as well as the same individual at different times, so that they will give rather large differences in threshold values. It has been shown that these differences are not due to changes in the experimental setting or in the sense organs themselves but are due to differences in the attitude of the subject—if by that we are agreed to mean the manner in which the subject accepts and understands the instructions.[1] It would seem, therefore, that a study of the way a subject accepts the instructions and the differences in reaction due to the differences in attitude thus created would be a proper form of behavioristic research.

It may be the ideal that any subject, animal or human—'scientist, post-office clerk, store-keeper, housewife' or even a poor graduate student—would have aroused, always and invariably, the attitude which the experimenter meant to imply by the instructions. But, unfortunately, one cannot be sure that this is the case and so one has to use various experimental controls to be sure that he has obtained the desired result. Unfortunately, I am not aware of any experimental control of attitude or thinking or 'implicit sub-vocal response' other than by introspection, in the present state of our knowledge at least. I should be glad to learn of some other method less laborious and less tedious and more 'objective' than systematic experimental introspection for determining whether a subject is now judging pressure on the finger tips and now kinæsthetic sensations in the wrists *when you told him to judge the weights*.

Weiss insists that introspection 'as an end result is hopelessly inadequate to reveal the inheritance factors, the environmental factors and the training factors, which are the causes of a given set of reactions.' I am quite in accord with him in this statement. I certainly realize the limitations of the introspective method and its inadequacy in all but its own sort of problem. But objective methods and introspective methods may be used and should be used to complement one another wherever possible—if for nothing more than as an experimental control. And it turns out in an

[1] Fernberger, S. W., 'An Introspective Analysis of the Process of Comparing,' *Psychol. Mono.*, Whole No. 117, 1919.

Fernberger, S. W., 'The Effect of the Attitude of the Subject upon the Measure of Sensitivity,' *Amer. J. of Psychol.*, 1914, 25, 538–543.

George, S. S., 'Attitude in Relation to the Psychophysical Judgment,' *Amer. J. of Psychol.*, 1917, 28, 1–37.

experiment, such as the determination of the difference limen to lifted weights in the anthropological unit of the post-graduate student in psychology at Clark University in the year 1921, that such an introspective control of the way the subjects interpreted the instructions proved to be necessary. And, from other work, we believe that it is necessary when dealing with other anthropological units.

Weiss does not criticize the experimental results of this study but merely the implications which have been drawn from them. The experiment was devised to study the effects of attitude on the psychometric functions. It was found that attitude had an effect in graduate students. If such an effect is present in graduate students, trained in scientific method, it is reasonable to speculate further that attitude will be much more likely to have an aff ct as one changes from the housewife to the post-office clerk, because these non-laboratory types are less amenable to constancy of reaction.

Weiss also insists that introspections 'are abnormal supplementary speech reactions of the same nature as illusions, dreams, etc.' If by abnormal, he means unusual in that they occur in a few individuals who have been specially trained, I would agree. But it would also seem to me that any scientific observation whatsoever or any scientist must be similarly abnormal. But I hope that his inclusion of introspections with 'illusions, dreams, etc.' is a verbal slip and is not to be taken literally.

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